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AN EVALUATION OF FAULT ISOLATION MANUALS FROM THE MAINTENANCE TECHNICIAN'S PERSPECTIVE

THESIS

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AFIT/GLM/LSM/90S-36

The opinions and conclusions in this paper are those of the author and are not intended to represent the official position of the DOD, USAF, or any other government agency.

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THESIS

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Preface

The purpose of this research was to investigate the F-16 Fault Isolation Manual from the maintenance technician's perspective. Evaluation considered the effect of various demographic factors and the maintenance technicians' perceptions on the Fault Isolation Manuals usefulness and accuracy.

The findings indicate that maintenance technician's who use the manual more perceive the manual to be more useful and accurate than technicians who use the manual less. The findings also determined that technician's have a perception that the manual has several inaccurate areas. Actions need to be taken to improve the accuracy of the F-16 Fault Isolation Manual system. Otherwise, the Air Force will not receive the full value of its investment to produce the manuals.

There are several people I would like to thank for their support and guidance through this fifteen month research process. First, I would like to thank my wife, Michelle, for her understanding during my term at AFIT. Next, I extend my sincere appreciation to Major David Diener, my advisor, and Lieutenant Colonel Phillip Miller, my reader. Without their guidance and assistance, this thesis would not have been possible. I would also like to thank the personnel in the F-16 System Program Office

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Abstract

Studies to improve the way technicians isolate malfunctions have been on-going since at least 1954. Some significant improvements have resulted in the paper based fault isolation manuals used by maintenance technicians. However, problems with the manuals persist. To evaluate how maintenance technicians perceive the F-16 Fault Isolation Manual (FIM), technicians from six CONUS F-16 wings were surveyed. The data were statistically analyzed by the demographic factors of skill level, AFSC, grade, education level, base of assignment, maintenance experience, F-16 experience, and FIM experience, to determine if differences existed as to the maintenance technicians' perceptions of FIM usefulness, FIM accuracy, and satisfaction with the FIM. The results indicate that 1) differences exist for all demographic factors except grade and base of assignment, 2) technicians who use the FIM more perceive it to be more useful and accurate, and 3) technicians with more experience and education perceive the FIM to be less useful or accurate and are less satisfied with the FIM. The recommendations are that actions need to be taken to ensure technicians use the FIM as directed and to improve the accuracy of the FIM.

AN EVALUATION OF FAULT ISOLATION MANUALS FROM THE MAINTENANCE TECHNICIAN'S PERSPECTIVE

I. Introduction

General Issue

It should not need to be stated that the successful accomplishment of an assembly or maintenance task requires usable and accurate instructions. Unfortunately, many cases occur where the information is unusable or inaccurate. Anyone who has worked on their own car or assembled a child's toy has experienced these problems. The instructions do not always provide all the information necessary to not only complete the job (usable), but to do so correctly (accurate). How critical this information can be was illustrated when the Gemini 9 spacecraft failed to attach to its target vehicle. The craft's connection was impossible due to improperly installed lanyards. The procedures for installing these lanyards "were found to be insufficiently detailed to insure proper installation..." (Vandenberg, 214). In the military, the need for usable and accurate instructions is even more pervasive. If the instructions are not usable and accurate, "a serious degradation in defense readiness and a tremendous increase in operation and maintenance costs could result" (Duffy and others, 143).

The volume of technical documentation in the Air Force is of staggering proportions and has been estimated to be growing at an exponential rate (Ventura, 81). "The number of technical orders [TOs] in the Air Force inventory in late 1985 was in excess of 130,000 unique titles comprising over 15 million pages" (Higbee, 10). For the B-1B aircraft alone, there are more than 7,000 manuals totaling over one million pages (Atkinson and Hiatt, A1). A specialized portion of the aviation manuals are the Fault Isolation Manuals (FIMs). The FIMs' primary purpose is to provide the technical information required to isolate (troubleshoot) and correct a fault detected by an aircraft's diagnostic system. The term fault describes any malfunction that occurs within an aircraft system. Malfunctions identified by an aircraft's diagnostic system have fault codes for specific faults. The fault code indicates the system and subsystem with the fault and what the fault is. Using the fault code, the technician can use the FIM to get a description of the fault and the procedures to isolate and correct the fault. If errors occur in isolating and correcting faults, they can impact the operations and support of a weapon system.

> Some of these errors can produce significant effects, e.g., abort an operation, require repetition of the troubleshooting and repair actions, waste spare parts, place an additional load on the maintenance activity, or perhaps lead to an injury or accident (Orlansky and String, 4).

Although it should be obvious that FIMs need to be usable and accurate to facilitate the repair of faults, several studies have established that as the size and complexity of a system increases, troubleshooting performance is degraded (Morris and Rouse, 507). If the FIMs are unusable or inaccurate, maintenance technicians will not be likely to use them which potentially impacts aircraft safety, reliability, and maintainability.

Background

TOs are the maintenance technician's primary source of information regarding the operation and maintenance of equipment. TOs are "the communications link between the [system] designer and the operator" (Johnson and Reel, 37). It was recognized over 35 years ago that aircraft system TOs needed improvement (Berkshire, 1954). Since then, numerous studies have attempted to improve the technical data maintenance technicians use in the performance of their duties. Details of these studies are provided in the literature review. Other studies have evaluated the maintenance technician's perceptions about improvements to TOs. These too are addressed in the literature review.

As a result of these studies, one of the TO improvements was the development of proceduralized job performance aids (JPAs) which are:

> . . . devices or documents that contain guidance information that helps the technician perform a particular job at hand, and are "people" rather than equipment directed. The aid may be a very specific step-by-step set of directions that require no decisions to be made or it may be something that gives a more general picture of the system and assists the technician in deciding what to do next. (Rowan, 9)

The FIM is a specialized type of JPA. The FIM as known today was developed in the late 1970s for use on the F-15 and F-16 to take advantage of their advanced built-in diagnostic systems.

In contrast to the numerous studies on previous TO improvements, the FIM has only been evaluated three times (Mussari, 1985; Gemas, 1985; and Gemas, 1988). These evaluations primarily focused on system (F-15, F-16) fault reporting and fault isolation, not just the manuals. As such, the studies were not performed to the same depth or scope as other TO improvement evaluations (Bialek, 1978; Johnson and others, 1977; Richardson, 1977; and Serendipity, 1969). The results of evaluating FIMs during the Mussari and Gemas studies are summarized in the statement by HQ USAF that "though FIMs have been in existence since the late 1970's, they still have not been fully accepted by maintenance technicians in the field" (Silva, 1989:1). The causes for this lack of acceptance of FIMs is unknown but could directly result in the FIMs' non-use by maintenance technicians.

The Air Force concern with FIM use is related to several issues. First, cost estimates for acquiring, adding or revising existing Air Force manuals is significant. The cost for acquiring TOs for the B-1B, F-16C/D and KC-135R were estimated to be $435 million (DOD, Appendix E). The cost for making changes to TOs has been estimated to exceed $70 million per year (Duffy, 1985:115). There are "approximately 2.3 million change pages generated annually to maintain TO accuracy" (Higbee, 10). At this cost, it is imperative that the Air Force know that it is acquiring a product that can and will be used. Second, future austere budgets will reduce the number of skilled personnel available to perform the maintenance on aircraft in the Air Force. The retention of these skilled personnel is declining because of their demand in the private sector and compounded by the availability of personnel to enter the Air Force. The demographic trend for the future shows that there is a predicted 20 percent decline of new workers (ages 18 - 24) entering the work force (McGrath, 16). This is already evident in some F-16 wings where three level manning is forecasted to reach 40 percent (Smith, 1990). If the FIM is not usable or accurate to these three level maintenance technicians, they have no experience to fall back on. This will slow the repair of the F-16 and ultimately affect aircraft availability. Third, inaccurate

FIMs will increase the use of spare parts. It has been estimated that "as much as 40 percent of the avionic equipments are unnecessarily removed from aircraft during maintenance activities" (Rue and Lorenz, 1). If the wrong part is removed to correct a malfunction as a result of erroneous FIMs, the burden of work on the maintenance and supply system is increased. In fact, it has been identified that significant logistics support is expended in troubleshooting, removing, retesting, and replacing serviceable avionics components thereby reducing aircraft availability and increasing total support costs (Demmy and Williams, 1982:3). This increased use of spares can result in the acquisition of unnecessary spare parts by the Air Force. Finally, maintenance specialties have changed the composition of Air Force manning. Maintenance specialties have increased "from an estimated 10 to 20 percent in the 1950s, to 20 to 30 percent in the late 1960s and early 1970s, and to nearly 40 percent by 1983" (Binkin, 7). These technicians have been estimated to spend "20 percent of their time seeking information, which when found is often inadequate" (Binkin, 103).

Any one of the preceding concerns is enough to warrant an FIM usage review. Taken together, they establish an irrefutable basis for accomplishing an FIM review.

Problem Statement

Because of the role of FIMs in the Air Force and the fault isolation process, it is important to know to what extent FIMs are used by maintenance technicians. This study determines the level of FIM use by technicians and investigates factors which influence their use of FIMs.

Scope

Aircraft FIMs are utilized on operational flightlines throughout the Air Force on a variety of systems and by several thousand maintenance technicians. This research focuses on maintenance technicians with the Air Force Specialty Codes (AFSCs) associated with flightline maintenance of the F-16 fighter aircraft assigned to bases within the continental United States.

Research Objective, Questions, and Hypotheses

The key element of this research is to determine to what extent the F-16 FIMs are used by maintenance technicians on the flightline. After establishing how much the FIM is used, the study investigates whether the use of the FIM is influenced by various demographic factors or by the maintenance technician's perceptions of the usefulness and accuracy of the FIM.

Research Objective. The objective of this research is to determine:

1. whether the technician's use of the FIM is related to the maintenance technician's perceptions of FIM usefulness or accuracy,

2. whether differences exist by demographic factor as to the technician's use of the FIM,

3. whether differences exist by demographic factor as to the technician's perceptions of the usefulness and accuracy of the FIM,

4. whether differences exist by the level of FIM use as to the technician's perceptions of the usefulness or accuracy of the FIM, and

5. whether differences exist by demographic factor as to the technician's satisfaction with the FIM.

Research Question 1. Is there a relationship between the maintenance technician's perceptions of the usefulness and accuracy of various features of the FIM and their use of the FIM?

Research Hypothesis 1.1. Maintenance technician's use of the FIM is positively correlated to their perceptions of the usability of the following FIM elements: illustrations, procedures, fault trees, troubleshooting logic, and indexes.

Research Hypothesis 1.2. Maintenance technician's use of the FIM is positively correlated to their perceptions of the accuracy of the following FIM elements: illustrations, procedures, fault trees, troubleshooting logic, and indexes.

Research Question 2. Are there differences by demographic factor on the technician's use of the FIM?

Research Hypothesis 2.1. The demographic factors of grade, AFSC, skill level, base of assignment, education level, aircraft maintenance experience, F-16 experience, and FIM experience, make no difference in the extent of technician's use of the FIM.

Research Question 3. Are there differences by demographic factor on the maintenance technician's perceptions of FIM usefulness or accuracy?

Research Hypothesis 3.1. The demographic factors of grade, AFSC, skill level, base of assignment, education level, aircraft maintenance experience, F-16 experience, and FIM experience, make no difference in the maintenance technician's perceptions of FIM usefulness.

Research Hypothesis 3.2. The demographic factors of grade, AFSC, skill level, base of assignment, education level, aircraft maintenance experience, F-16 experience, and FIM experience, make no difference in the maintenance technician's perceptions of FIM accuracy.

Research Question 4. Are there differences by level of FIM use as to the maintenance technician's perceptions of FIM usefulness and accuracy?

Research Hypothesis 4.1. The level of FIM use makes no difference in the maintenance technician's perceptions of FIM usefulness.

Research Hypothesis 4.2. The level of FIM use makes no difference in the maintenance technician's perceptions of FIM accuracy.

Research Question 5. Are there differences by demographic factor as to the maintenance technician's satisfaction with the FIM?

Research Hypothesis 5.1. The demographic factors of grade, AFSC, skill level, base of assignment, education level, aircraft maintenance experience, F-16 experience, and FIM experience, make no difference in the maintenance technician's satisfaction with the FIM.

Summary

This chapter introduced the basic concepts of the FIM and the factors which impact their use, specifically the perceptions of whether the FIM is usable and accurate. After a discussion of the background pertaining to FIM development, the specific problem this study addresses was identified. An outline of the scope of the study followed this discussion. The chapter concluded with identification of the research objective, questions and hypotheses formulated to assist the researcher in providing insight into the use of FIMs by maintenance technicians.

II. Literature Review

Introduction

Technical orders (TOs) are the maintenance technicians' primary source of information regarding the operation and maintenance of equipment. Therefore, the TOs' accuracy and usability are of prime importance to maintenance technicians (Almeida, 9). It has been estimated that up to 75 percent of a maintenance technician's time is spent diagnosing system failures (Rasmussen, 113) and one of the key tools used in diagnosing systems is the fault isolation manual (FIM). FIMs are a specialized portion of TOs called Job Performance Aids (JPAs).

Folley reports that it is difficult to determine when the term JPA was developed but it came into prominence in the 1950s. Folley goes on to identify the reason for the development of JPAs.

> During this period, behavioral researchers at the Air Force Personnel and Training Research Center in Colorado realized that (1) many of the technical jobs in the military were procedural and (2) the approach to the development of technical manuals was inadequate (Folley, 1972)

It was also during the 1950s that Miller emphasized an analysis of the job in order to develop complete and concise job instructions that were compatible with the characteristics of the user population (R. Miller, 1954: 34). Since the 1950s, TOs and JPAs have had numerous studies completed to assess their usefulness to maintenance technicians. Unfortunately, problems with the manuals persist.

Over the years, maintenance technicians have expressed their dissatisfaction with the currency or adequacy of maintenance TOs (Rasmussen, 119). It is generally acknowledged among maintenance technicians and personnel engaged in TO research that the present Air Force technical orders are hard to use (R. Johnson, 1977:7; Kirsch, vi; Thomas, 1978:5, Thomas, 1990). The development of newer and more complex weapon systems has caused the information concerning these systems to proliferate (K. Johnson and others, 5). These new systems "are dependent upon sophisticated fire control, weapons delivery, navigation and display systems to provide pilots with the capacity to accomplish their missions" (Gemas, 1983:1). The Department of Defense recognizes the importance of proper technical data and has established policies to ensure technical information is accurate, current, and comprehensible. (Kincaid and others, 7). Just how important this technical information can be is illustrated by a review of fighter aircraft accidents.

From January 1980 to October 1989, fighter aircraft (A-7, A-10, OA-37, F-4, F-5, F-15, F-16, and F-111) have experienced 549 accidents or incidents (Class A, B, or C) in which investigation identified inadequate or incorrect technical data as a finding (A finding is not to be construed as having been the cause of the accident). Of these 549, 81 were Class A accidents which means loss of aircraft or loss of life (HQ AFISC, 1). If even ten percent of these technical data findings contributed to the cause of these class A accidents, then more accurate technical data could have saved lives and approximately 100 million dollars of aircraft. From this illustration, it is easy to understand the importance of technical data, and more importantly the need for accurate technical data.

This chapter chronologically reviews literature associated with TOs used in troubleshooting and the maintenance technicians' attitudes towards them. The first section, or what is addressed as the past, deals with those studies that have been completed and are associated with paper based maintenance aids. The second section, the present, addresses those research efforts that are associated with electronic maintenance aids. The final section, the future, reviews literature that indicates future trends in area of maintenance aids.

The Past

1954 Miller. This study was initiated for the purpose of developing a program for human engineering improvements to the maintainability of ground electronics equipment (Miller and others, 1). Through interviews and surveys of ground electronics technicians, the researchers identified the need for further research in the area of trouble shooting (Miller and others, 19). Specifically, the researchers concluded that:

> as a supplement to any hardware provisions for trouble-shooting, technical reference materials should be provided. The purpose of the diagrams and sentences in these aids should be to facilitate the trouble-shooter in making decisions which permit him to track down the trouble with the fewest and easiest steps. (Miller and others, 20)

<u>1954 Berkshire</u>. Another early study on JPAs by the Air Force was in 1954 by James R. Berkshire for the Air Force Personnel and Training Research Center (AFPTRC). This study concerned "the development and preliminary evaluation of a set of routine or "cookbook" troubleshooting materials for a particular type of complex electronic equipment [radar set]" (Berkshire, 2). The materials developed were of such detail that a mechanic did not need a complete understanding of the functional relationships of the radar set (Berkshire, 2). Troubleshooting of two different malfunctions was performed by 18 trained mechanics with varying experience from seven to thirty-one months. A second group of six, who had received initial training but had little maintenance experience, was also tested (Berkshire, 5). For one malfunction, the mechanic used his own methods for isolating the malfunction and for the other used the developed troubleshooting material (Berkshire, 5). The troubleshooting materials saved an average of two hours per

malfunction when used by all the technicians including those who had completed maintenance training but had no on-the-job experience isolating faults (Berkshire, 6-7). The use of the troubleshooting materials by the experienced technicians also reduced the number of components removed by approximately 75 percent (Berkshire, 6).

<u>1958 Warren</u>. In another AFPTRC sponsored study, Neil D. Warren and others attempted to determine if:

> an effective and logical troubleshooting aid for complex systems [Bombing-Navigational System] could be developed for use by relatively inexperienced flight-line mechanics. (Warren and others, iii)

Two methods were used in the development of this aid. The first was a systems-oriented approach in which a card represented a major system component and possible symptoms of the component's malfunction were coded along the card's edge (Warren and others, 3). The second approach was procedure-oriented, one similar to the procedural checklists of a preflight/postflight checkout of the system (Warren and others, 7). The two aids were tested at two Strategic Air Command wings by ten system technicians (Warren and others, 6). The result of the evaluation was that the procedure-oriented approach was the preferred method though the technicians felt the systems approach had better isolation procedures and covered radar malfunctions better (Warren and others, 22-23).

1958 Folley. In a literature review of JPAs, Folley and Munger report on two unpublished experimental studies accomplished by Hoehn and Aukes in 1958 concerning troubleshooting (Folley and Munger, 28). The objective of the first study was:

> to test the effectiveness of a [troubleshooting] guide in supporting performance of troubleshooting tasks by unskilled men. The purpose of the second study was to compare the effectiveness of three different types of arrangements of procedural instructions for troubleshooting. (Folley and Munger, 28)

The results of these experiments were that the troubleshooting ability of untrained, and to a lesser extent, trained, men can be increased through the use of procedural instructions (Folley and Munger, 29).

1962 Losee. In 1962, the USAF Aerospace Medical Research Laboratory performed a study which analyzed the basis for maintenance technician complaints about TOs and examined all phases of the TO system. The study results came from surveys and interviews of 2300 supervisors and maintenance technicians located at 19 Air Force organizations working on a wide variety of weapon systems (Losee and others, 14). One of the objectives of the survey was "to identify weaknesses in the content, and utilization of Air Force maintenance technical data" (Losee and others, 1).

The results indicated that use of the TO by skill level was dependent on the task being accomplished. For equipment adjustment, repair, servicing or checkout, and troubleshooting, technicians with higher skill levels made more frequent use of TOs. The lower skill levels used the TOs more frequently for equipment inspection and replacement. In evaluating the TOs for troubleshooting, the results indicated an:

> ...affirmation by 60% of the maintenance men that the biggest single assist to them in troubleshooting would be the establishment of a more effective procedure or scheme for isolating malfunctions. Other responses indicated that better feedback of trouble from the field for timely inclusion in subsequent T.O.'s would be eminently desirable. In the types of data desired to be improved to make malfunction correction easier and quicker, 38% selected better and more complete schematics while 35% wanted more step-by-step written procedures. (Losee and others, 21)

From the study, a large percentage of maintenance technicians identified the same weaknesses in TOs (Losee and others, 14). The survey responses identified "a need for change in the size, structure and content of T.O.s, to make them more useful both as a training text and as a job performance aid" (Losee and others, 16). To make TOs more effective, the study recommended:

1. More step by step instructions.
2. Better (more accurate) and more complete schematics.
3. A means of upgrading technical data to reflect field experience.
4. TOs which do not require referral from one to another to get required information.
5. More TOs in the form of checklists, work cards, and pocket size books which will be available for immediate reference on the job.
6. A revised numbering and indexing system that will simplify the task of locating the needed information. (Losee and others, 17)

1965 Human Resources Research Office. The Army's first research into proceduralized TOs was accomplished under the title MAINTRAIN. "Its objectives were to develop a type of maintenance manual which would permit trained technicians to troubleshoot modern complex electronic equipment faster and more accurately, and to specify procedures for preparing such manuals" (Rogers and Thorne, 4). After developing a hypothesis as to what information should be included in a troubleshooting manual and how the information should be presented and organized, an experimental manual was developed (Rogers and Thorne, 4). The manual was tested and evaluated on the Nike Ajax missile system. The results indicated that technicians were able to locate 42 percent more electronic malfunctions using the experimental manual (Rogers and Thorne, 26). This led to the conclusion that "substantial increases in the speed and effectiveness of troubleshooting could be obtained through the use of improved troubleshooting manuals" (Rogers and Thorne, 28). The manual differed from current conventional manuals available at that time by providing additional information and organizing the information based upon when and how the information is used during troubleshooting (Rogers and Thorne, 28).

1969 Project PIMO. The Presentation of Information for Maintenance and Operations (PIMO) project was an Air Force study conducted from 1964 to 1969 and is considered the most extensive research effort performed in the job aid area (Rowan, 21). The study attempted to prove that a proceduralized job guide technical orders system for non-troubleshooting and troubleshooting tasks would reduce maintenance manhours and increase the reliability of troubleshooting for apprentice (three-level) technicians (Serendipity, 6). In other words, it took action on developing a proceduralized job guide as a result of the previous experiments and studies relating to proceduralized job aids. This proceduralized data provided all relevant information for a task on two facing pages of a pocket sized book. The proceduralized instructions were short, step-by-step, easy to read and always presented on the left side of the text and the illustrations for the instructions were always presented on the right.

The PIMO field study compared experienced and inexperienced personnel utilizing job guides and was conducted on C-141 aircraft at Charleston, Dover, and Norton Air Force Bases. The study findings were:

1. Apprentices can perform as well as experienced specialists when both groups use PIMO Job Guides.
2. Both experienced specialists and apprentices showed strong evidence of learning while performing with the PIMO Job Guides.
3. It was noted that apprentices using PIMO Job Guides outperformed specialists using technical orders as guides.
4. When apprentices attempted to follow Technical Orders they committed numerous errors. Often they could not even complete the activity.

5. The PIMO troubleshooting aids resulted in an 11 percent reduction of performance time and 92 percent reduction in maintenance errors. (Serendipity, 13-14)

From these results, it was determined that the use of job guides could increase maintenance manpower availability for productive maintenance labor by 50 to 100 percent. This increase in productive maintenance could reduce unscheduled maintenance by 37 to 44 percent and increase the operationally ready rate by 38 to 40 percent (Serendipity, 15). The PIMO troubleshooting aid showed an 11 percent reduction in time using PIMO aids versus conventional aids (Serendipity, 13).

1970 McDonnell Douglas. For the then newly developed DC-10, the McDonnell Douglas Aircraft Company developed a comprehensive fault detection/fault isolation system. The DC-10s fault isolation goals were to "1) provide fault isolation to a single LRU [Line Replaceable Unit], 2) provide in flight fault isolation, and 3) provide on the ground fault isolation when required" (Adams and Bayer, 137). The fault isolation system for the flight portion was based on a Flight Engineers Fault Isolation (FEFI) manual. This manual used a color coded pattern recognition system for each aircraft system and a failure pattern reporting code for each pattern. Acceptance of this manual by flight crew members was highly favorable. (Adams and Bayer, 137).

A Turnaround Fault Isolation (TAFI) manual was the key element for the ground maintenance portion of the fault isolation system. This manual provided:

1. A duplicate (though uncolored) of the in-flight pattern recognition chart, with the required on-ground fault isolation "fault tree" (if any) associated with each report code. The fault tree also identifies the part most likely to be at fault.
2. A location and access diagram for all system components, including switches and circuit breakers.
3. System schematics, for system understanding and fault isolation of wiring or other noncomponent failures. (Adams and Bayer, 138)

During tests of the TAFI using DC-10 maintenance simulators, troubleshooting time was reduced by 66 percent and troubleshooting accuracy was improved by 90 percent (Adams and Bayer, 138). Other improvements included a need for only one-tenth of the fault isolation documentation previously needed, fleet operations savings of approximately $58 million per year, and a 16 percent reduction in system removal rates (Adams and Bayer, 138-139).

<u>1971 Jarmen and Weaver</u>. In 1971, two AFIT students, Captains Jarmen and Weaver, analyzed the usefulness of the technical aids in the Air Force Communications-Electronic-Meteorological (CEM) maintenance area. The objective was:

> to examine and relate the results of prior research in instruction presentation techniques to the current and projected Air Force ground CEM maintenance environment. The authors believe that the value of any maintenance instruction stems from the following: congruity between the maintenance environment and the maintenance

aid design, and an enlightened effort to make the aid useful and acceptable to the maintenance technician. (Jarmen and Weaver, 12)

Jarmen and Weaver's conclusions included the following:

1. The design of USAF CEM maintenance TOs had not kept pace with changes in equipment or with advances in performance aid technology. (Jarmen and Weaver, 62)

2. Problems with TOs identified in the 50's and 60's persist. "Many TOs simply do not reflect a consideration of the technician's needs" (Jarmen and Weaver, 63).

3. Information of little use to technicians during troubleshooting, such as design specifications, drawings, and schematics, are contained in TOs. (Jarmen and Weaver, 63)

Part of their study was a survey designed to relate technicians' attitudes to changes in maintenance instruction design (Jarmen and Weaver, 40). Survey responses indicated that technicians' attitudes toward the value of a TO were influenced primarily by the aid's contribution to job performance. Additionally, technicians' attitudes were influenced by the design of the aid (Jarmen and Weaver, 66).

1972 AFLC Technical Order Improvement Program. In 1972, the Air Force Logistics Command (AFLC) initiated its Technical Order Improvement Program to replace the traditional TOs on selected older aircraft. Under this program, proceduralized TOs for the C-141, B-52, KC-135, and F-106 were procured. Shortly after this, Headquarters Air

Force directed that all new weapon systems would have proceduralized job guides for organizational maintenance (R. Johnson and others, 8).

1975 Shriver. In 1971, "as part of the Vietnamization program, three types of job performance aids (JPA) were developed to support organizational (flight line) maintenance of the UH-1H helicopter by personnel of the Vietnamese Air Force (VNAF)" (Shriver, 1). Two evaluations of the JPAs were conducted using USAF and VNAF personnel with varying levels of training and experience. The evaluations addressed both non-troubleshooting and troubleshooting JPAs. Only the troubleshooting results of the evaluation are reported.

The troubleshooting evaluations compared the performance of technicians on 3 maintenance tasks using the JPA or conventional technical manual (TM) (Shriver, 2). This troubleshooting JPA was similar to the JPA used during Project PIMO. For the USAF technicians, it was not until the troubleshooting JPA had been modified three times that the technicians performed better using the JPA than the conventional TM. The most dramatic increase in performance using the JPAs over TMs was for the novice users; a novice is a technician who has completed basic military training but has no UH-1H training or experience (Shriver, 29). The novice success rate increased 18 percent whereas the experienced technician success rate increased by 7 percent (Shriver, 2).

The most significant improvement for the VNAF technicians occurred with the apprentice technicians who had received formal training but had no experience. The apprentices' success rate improved by 15 percent using the troubleshooting JPA. This improvement using the troubleshooting JPA led to a 100 percent success rate in identifying failures (Shriver, 2). Experienced VNAF technicians performed equally well using either the JPA or conventional TM (Shriver, 29).

1975 Holbert. In 1974, the U.S. Army Air Mobility Research and Development Laboratory (USAAMRDL) contracted a study to:

> identify and evaluate the attributes that cause loss in maintenance effectiveness by incurring repetitive actions and incorrect diagnoses of components at the organizational level of maintenance. (Holbert and others, 10)

This study was driven by an observation that "over 50% of Army aircraft maintenance diagnoses at organizational level were reported as being incorrect" (Holbert and others, 24). A survey was administered to over 940 maintenance technicians at six U.S. Army posts. From survey analysis, some of the study conclusions were: 1) Test equipment is not being used to troubleshoot maintenance problems and the procedures were incomplete, 2) Troubleshooting procedures in maintenance manuals covered only expected problems, thus leaving remaining problems to be resolved by trial-anderror procedures that were costly and time-consuming, and 3) Trial-and-error troubleshooting methods are used up to 50 percent of the time in resolving a maintenance problem. (Holbert and others, 119)

The major recommendation relating to TOs was that "maintenance manuals should be revised to provide improved and expanded troubleshooting procedures" (Holbert and others, 120).

1975 Johnson. In 1975, the Air Force Human Resources Laboratory (AFHRL) initiated a study at Norton and Charleston Air Force Bases to assess the usability and user acceptance of the C-141 proceduralized TOs or job guides as they are more commonly known. The purpose of the project was to answer:

> 1. How well are the job guides accepted by using personnel? What characteristics do the technicians like? What characteristics do they dislike?
> 2. Are the job guides usable? What characteristics make them easier to use? What characteristics hinder their use?
> 3. What problems are encountered in implementing the job guides? How can problems encountered be corrected and avoided in future job guide programs? (R. Johnson and others, 7)

The results of interviews, observations, and surveys indicated that:

> The JGMs [Job Guide Manuals] and LTTAs [Logic Tree Troubleshooting Aids] generally have been well accepted, although some resistance to change was encountered. The new technical data have generally

> been considered to be superior to the technical orders that they replaced. (R. Johnson and others, 1)

Several factors were identified that had either a positive or negative effect on the acceptability and usability of the job guides. The positive factors were the manuals smaller size, illustrations supporting the procedures, manual format - good illustrations keyed to task steps, input conditions page - specifies tools, equipment, personnel, and spares to start the task, and reading level - removal of unnecessary information. The negative factors were lack of familiarity with the job guide series (inadequate training), confusion over proper usage of job guides, inadequate storage of job guides on aircraft, lost or misplaced job guides, use of danger tags, lengthy checkout procedures, incomplete troubleshooting data (did not contain all the malfunctions), difficulty in locating specific information, too many books required for one job, errors in the books, resistance to change and durability (R. Johnson and others, 25-27).

The results of the survey for maintenance technicians' opinions about LTTAs are especially important since the LTTAs are the precursor to the FIMs in use today. The results for the question on whether the LTTAs lead to correct isolation of the problem show that 54.8 percent of the technicians surveyed felt the LTTAs always or usually led to correct solution of the problem. Analysis of this question by AFSC varied from a low of 27.5 percent to a high of 78.5 percent. From these results, the researchers concluded that the LTTAs did not effectively isolate malfunctions (R. Johnson and others, 50).

1977 MIL-M-83495. In 1977, the Department of Defense developed and implemented a new military specification, MIL-M-83495, Manuals, Technical, Organizational Maintenance Manual Set.

> The new specification contained requirements designed to resolve complaints uncovered in the 1962 and 1975 studies. MIL-M-83495 arranges maintenance data into broad categories, which when put together, create an "organizational maintenance manual set" required for aircraft maintenance. Seven distinct type of manuals result from this arrangement: general vehicle manual, general systems manuals, fault reporting manual, fault isolation manuals, schematic diagram manuals, wiring data manuals, and job guide manuals. (Mussari, 2)

1977 Richardson. In 1977, two AFIT students, Lieutenant Colonel Richardson and Captain Syster, performed a study to:

> determine if user acceptance and perceived usability of the C-141A Job Guides were as favorable at other MAC bases as they were at the two bases which participated in the development and initial implementation of the C-141A Job Guides [reported under 1975 Johnson]. (Richardson and Syster, 2)

They surveyed 320 maintenance technicians at McChord And McGuire Air Force Bases, two bases that were not previously involved in either the development of job guides (PIMO) or evaluation of the usability and acceptability of job guides

(1975 Johnson). The survey questionnaire was intentionally made similar to the 1975 Johnson study survey to make a comparative analysis possible (Richardson and Syster, 68).

The conclusions of the study are summarized as follows:

1. In general, maintenance technicians had a favorable attitude toward job guides over other forms of technical data. However, responses indicated that some technical problems still existed (Richardson and Syster, 163-164).

2. User acceptance of the job guides was slightly lower than that measured by the AFHRL survey. However, acceptance was still generally high (Richardson and Syster, 165).

3. In assessing the usability of the job guides, they found that the perceived usability of C-141A Job Guides was generally very favorable (Richardson and Syster, 166).

4. The relationship between pay grade and acceptance of job guides was that "lower grade technicians do not have a significantly higher degree of acceptance of the job guides than do higher grade technicians" (Richardson and Syster, 167). An item of interest should be noted on this research hypothesis of lower grade technicians having a higher degree of acceptance for job guides than higher grade technicians. Support or non-support of this hypothesis was provided by five statistical hypotheses and a finding of statistical significance for a particular pair of the five hypotheses was considered critical for the support of the

research hypothesis (Richardson and Syster, 94). When one of the pair did not test to be statistically significant, the researchers made the previously stated conclusion although three of the five hypotheses tested to be statistically significant and a fourth research hypothesis had movement in the predicted direction (Richardson and Syster, 137-138). Movement in this case refers to the prediction that higher grade technicians use job guides less than lower grade technicians.

5. There was little significant difference between pay grades and perceptions of the usability of the job guides. They concluded that a technician's perception of the usability of job guides did not vary with pay grade (Richardson and Syster, 148).

<u>1978 Thomas</u>. This report was published in 1978 but the research covers the period June 1974 to March 1978. The survey questionnaire was distributed prior to the 1975 AFHRL study. Using the same questionnaire and procedures as the 1962 AMRL study, the AFHRL personnel measured "the attitudes of maintenance technicians toward conventional TOs prior to their replacement by an improved technical manual system, called job guides" (Thomas and others, 5). Some of the significant findings were:

1. In 1962, 32% of the technicians reported that TOs were fine as is; by 1975, that figure had dwindled to 13%.
2. In 1962, 51% of the maintenance personnel indicated that TOs were adequate for troubleshooting, while

the 1975 [study indicated] only 37% so indicated [that TOs were adequate for troubleshooting].
3. Estimates of TO use in troubleshooting tasks declined by 10% to 15%.
4. An increase in the judged need for TO improvement: 66% said yes to such a need in 1962; 79% in 1975. (Thomas and others, 6)

In considering the change in technicians' opinions about the use of TOs for troubleshooting, the researchers interpreted this finding to have occurred as a consequence of the increased complexity of weapons systems. Though weapon systems had changed, TOs, with the need for more detailed troubleshooting instructions and improved quality, had not. (Thomas and others, 6)

<u>1978 Bialek</u>. Two AFIT students, Captains Bialek and Kulas, studied the acceptance and usability of C-141 Job Guides at Altus and Travis Air Force Bases where job guides and conventional TOs were in use concurrently (Bialek and Kulas, 1978:2). They surveyed 150 maintenance technicians from each of the two bases (Bialek and Kulas, 24). The following summarizes the results of their study:

1. The overall preference for the job guides over conventional TOs was statistically significant (Bialek and Kulas, 73).

2. Maintenance technicians' opinions showed a strong degree of positive acceptance of job guides (Bialek and Kulas, 74).

3. In general, job guides were perceived to be more usable than conventional TOs. However, the troubleshooting

aids were not considered as usable as some of the other Job Guide features (Bialek and Kulas, 74-75).

Because responses to the survey questions concerning LTTAs were either negative or indecisive, the researchers recommended a more detailed study into the troubleshooting aspects of the job guides (Bialek and Kulas, 75). To date, no other studies have been performed on the LTTAs or FIMs.

<u>1978 Bunch</u>. This study by three AFIT students, Captains Bunch, Holsen, and Ward, had the objectives of: (1) assessing the attitudes of maintenance technicians with respect to the technical data they use, (2) comparing the results of this survey with the results of the 1962 AMRL study of the United States Air Force (USAF) maintenance technical data system, and (3) comparing the attitudes toward the technical data for newer weapon systems (i.e., C-5 and F-15) against those for older weapon systems (i.e., C-130 and F-4) to determine if technical data for new weapons systems are perceived to be better than, equivalent to, or worse than, the technical data for older weapons systems (Bunch and others, 6). They developed a survey instrument based on the 1962 Losee study and administered it to 600 maintenance technicians at Pope, Dover, Wurtsmith, F.E. Warren, Langley and Shaw Air Force Bases (Bunch and others, 23).

For the first objective, survey results indicated that although there was dissatisfaction with the depth of TO information relating to troubleshooting, technicians relied upon TOs as step-by-step procedural guides in the performance of daily tasks. Technicians also reported that the technical data they used were current, accurate, and compatible for the equipment maintained (Bunch and others, 75-76). For the second objective, it was concluded "that USAF maintenance technical data have not improved since the 1962 AMRL study was accomplished" (Bunch and others, 77). For their third objective, statistical testing failed to conclude that TOs for newer weapon systems are better than TOs for older weapon systems (Bunch and others, 77).

1983 Hughes. The Navy contracted with Hughes Aircraft Company from November 1976 to January 1978 to "obtain concise, definitive statements of maintenance and operation technical data (MOTD) problems from the point of view of the MOTD user in the fleet" (Hughes, S-0). To this end, Hughes surveyed and interviewed 427 seamen assigned to ships of the Pacific Fleet (Hughes, S-1). The survey addressed numerous areas relating to the use of technical data in the completion of maintenance activities. Only those areas relating to this research effort will be summarized.

The complaints about MOTD were that troubleshooting procedures did not work, it was difficult to fault isolate because fault isolation paths were circuitous or too long, and the symptoms and malfunctions listed were rarely the ones that occurred in the operating environment (Hughes, 3-18). An interesting insight was identified from this study. The MOTD system uses three different fault isolation techniques: step-by-step procedures, symptom-table method, and flow charts. Over 45 percent of all technicians preferred the step-by-step procedures. This is the same method the Air Force uses. Electronic technicians preferred this method three to twenty times more than the other two methods (Hughes, 3-21). Although electronic technicians preferred the step-by-step procedures, fifty percent reported that these procedures needed improvement (Hughes, 3-31).

1983 Nielsen. After evaluating the success of the Air Force in its development of JPAs, the Army developed and implemented their own proceduralized technical manual (TM) system called skilled performance aids or SPAs (Nielsen, 48). In 1981, because of complaints about the M1 tank SPA manuals, the Army tasked the Army Materiel Systems Analysis Activity (AMSAA) to evaluate what improvements could be made to Army proceduralized TM documentation (Nielsen, 8). AMSAA focused their study on five weapon systems and 14 TMs using a combination of surveys and interviews of 145 maintenance technicians from five posts. Two areas of concentration for their study were the TMs usability and usefulness in troubleshooting (Nielsen, 12). The results of this study indicated that the surveyed soldiers believed the new TMs were useful, particularly the step-by-step instructions and numerous illustrations (Nielsen, 25). However, the TMs troubleshooting/fault diagnosis remained a problem for complex items (Nielsen, 29,42).

1983 Duffy. A research study by the Navy Personnel Research and Development Center was designed to "evaluate the extent to which the theory description section of a TM [technical manual] can be made more comprehensible by applying user-oriented design strategies" (Duffy and others, 145). The design strategies for the text were developed by three contractors whose objective "was to redesign the material to maximize comprehensibility" (Duffy and others, 146). While not specifically addressing texts used in troubleshooting, this study did evaluate the effectiveness of the redesigned texts for inferring the reason for a system fault as a result of using the new texts. The redesigned texts were evaluated by 379 electronics technicians in their last month of apprentice training (Duffy and others, 146).

Although each contractor used extensive restructuring and rewriting of the materials, none of the redesigns led to improved comprehension of the text (Duffy and others, 156). The findings indicated that "difficult texts are not necessarily made more comprehensible by resequencing and reformatting the information" (Duffy and others, 159). The researchers concluded that the use of the text and the users of the text need to be considered before any redesign action.

1984 Chenzoff. The AFHRL contracted for an Air Force wide study, active duty and Guard/Reserve, to determine the factors which influence Air Force maintenance. To accomplish this study, the contractors performed 1,469 interviews at 15 bases encompassing six major commands (Chenzoff and others, April 1984, i). One of the specific areas addressed during this study were TOs and troubleshooting procedures. The findings for the study in the area of troubleshooting were:

1. Technicians noted that during troubleshooting they found what they wanted but it lacked sufficient detail (Chenzoff and others, April 1984, 132).

2. Every system troubleshooting TO drew a few complaints about "readability, clarity, organization, errors, ambiguity, and complexity" (Chenzoff and others, April 1984, 132).

3. Many technicians praised the Job Guides "for providing sufficient detail to lead even the most inexperienced troop through a task, and for presenting the material well" (Chenzoff and others, April 1984, 132). However, most experienced personnel resented the extra

detail because it didn't allow for a chance to use their knowledge or improve the procedure (Chenzoff and others, April 1984, 132).

4. Technicians whose jobs require them to troubleshoot were dissatisfied with the troubleshooting coverage of their TOs. Technicians said they helped find "only basic malfunctions and that 99% of the time you can't find the answer in them" (Chenzoff and others, June 1984, 99).

5. Fault isolation procedures needed more locator illustrations (Chenzoff and others, April 1984, 132).

6. Technicians wanted less rigid fault isolation procedures so there would be some way "for an experienced person to enter procedures in the middle, instead of always having to go back to "square one" (Chenzoff and others, April 1984, 133).

7. Some technicians admitted to carrying around a "bootleg" performance aid. Because of shortcomings of the TOs, technicians make their own devices, like fault isolation tables, which are perceived as more useful than a pile of TOs (Chenzoff and others, April 1984, 133).

8. Some technicians believed that training on TO use was as much at fault as the TOs themselves. Although technical schools often teach with TOs, they didn't teach how to use the TO system (Chenzoff and others, April 1984, 133).

1984 Mussari. The Air Force Logistics Management Center (AFLMC) performed a study to determine if the accuracy of the F-15 fault reporting/fault isolation (FR/FI) manuals was a factor in the manual's non-use. Data were gathered from 198 inflight discrepancies for a 30 day period from the 33rd Tactical Fighter Wing, Eglin AFB, Florida (Mussari, 5). The FI manual's accuracy was analyzed by comparing the action taken to repair the discrepancies to the repair action suggested in the appropriate FI manual. The results of this analysis concluded that inflight malfunctions could be accurately isolated in the FI manual 77.7 percent of the time (Mussari, 15). Based on the results of the study, it was believed that there were other causal factors which could account for non-use of the FI manual. These were:

> 1. Users' perceptions of wasted time, additional burden, and doubt as to system capability, has created a lack of confidence in the FR/FI system.
> 2. Users have little confidence that credible benefits can be derived from using the system properly. The primary reason for non-use of the system lies in the lack of confidence and understanding in the system by both operations and maintenance personnel, not the accuracy of the manuals. (Mussari, 16)

1985 Chenzoff. In 1983, the Navy contracted a study to evaluate the current status of technical manual (TM) use by fleet technicians and factors influencing TM acceptance, utilization, and effectiveness (Chenzoff and Joyce, iii). Generally, the acceptance of the Navy TMs was good but they were underused (Chenzoff and Joyce, 9). Part of the problem was the deficiencies noted for the proceduralized job aid for troubleshooting. Technicians reported little confidence in the aids accuracy and ability to save them time and trouble (Chenzoff and Joyce, 4). An interesting finding about the TMs was that acceptance of the technical publication was found to be positively correlated with rank. It was hypothesized that this was a result of the more senior personnel being more familiar with technical publications and they had better reading skills and manual usage (Chenzoff and Joyce, 2).

<u>1985 Gemas</u>. The Air Force Logistics Management Center (AFLMC) evaluated the use of the F-16 FIMs to determine the following:

1. How often does the Fault Recording Manual lead to an accurate fault code?
2. How often do fault isolation logic trees lead to the right corrective action? (Gemas, 1985:4)

Using the F-16 Central Data System as a data source, AFLMC used a ten percent sample of over 10,000 aircrew generated write-ups as their data base. Each write-up was evaluated on the following criteria:

-Not in the scope of the manuals.
-Specific fault coded - corrective action agrees with the FI.
-Specific fault coded - corrective action disagrees with the FI.
-General fault coded - no logic tree in the FI.
-Insufficient information in narratives to analyze.
-No malfunction, pilot or maintenance error.

-Maintenance corrected the write-up with a cannot duplicate (CND) or similar entry.
-False removal, component bench checked serviceable or RTOK. (Gemas, 1985:5)

A total of 991 write-ups could be analyzed and were within the scope of the fault reporting manual (Gemas, 1985:5).

The conclusions of the study were that the F-16 FR/FI manuals are inaccurate and require improvement. Specifically,

1. "Almost one-half (42%) of the fault codes currently developed by debriefers are inaccurate" (Gemas, 1985:13).

2. "Based on current debriefing practices, the maintenance technicians have a one-in-four (24.5%) chance at a valid corrective action" (Gemas, 1985:13).

3. "The fault isolation manuals have approximately a 10% error rate" (Gemas, 1985:13).

4. The AFTO 22 system is too slow. Up to 255 days are allowed for the incorporation of changes into the fault reporting and fault isolation manuals (Gemas, 1985:13).

<u>1988 Gemas</u>. The Air Force Logistics Management Center (AFLMC) evaluated the use of F-15 fault reporting/fault isolation (FR/FI) manuals to examine the accuracy of these manuals when used as intended. Data were gathered from over 1000 workorders for a nine month period at a National Guard unit transitioning from F-4 to F-15 aircraft (Gemas, 1988:i). The data were used to determine if:

1. Fault Reporting (FR) manuals accurately describe maintenance malfunctions, i.e. generate accurate fault codes.
2. Fault Isolation (FI) manuals provide an accurate assessment of the reported fault, i.e., identify the proper corrective action. (Gemas, 1988:3)

The results from data analysis are summarized as follows:

1. The FR manuals were 100 percent accurate.
2. The FI manuals were 74 percent accurate.
3. Thirteen percent of the corrective actions disagreed with the FI manual but corrected the problem.
4. Thirteen percent of the corrective actions were CND.
5. Two percent of the pilot reported discrepancies had a general fault code (system identification only) with no corresponding fault isolation logic tree in the FI manual.
6. One percent of the fault codes did not cross reference from the FR manual to the FIM. (Gemas, 1988:8-9)

1990 Silva. Results of the Coronet Warrior I exercise, an exercise to validate the availability of War Readiness Spares Kits, suggested that fault reporting/fault isolation (FR/FI) problems "might have a serious impact on flying operations" (Silva, 1990:1). Because of this finding, the AFLMC was tasked to participate in the Coronet Warrior II exercise and attempt to quantify this supposition through the collection of additional avionics repair data.

FR/FI data was collected during the Coronet Warrior II exercise at Shaw AFB, South Carolina from 10 May through 16 June 1988. The data collected:

> was analyzed to determine the accuracy of the fault isolation manuals based on given fault reporting codes. The data was also examined to find potential FR/FI

problems to be remedied by the appropriate ALC or contractor. (Silva, 1990:3)

A total of 357 inflight discrepancies were recorded but only 109 discrepancies, 30.53 percent, provided the necessary information for use in analysis (Silva, 1990:9). An additional finding for the 357 discrepancies was that 47.8 percent were labelled as general fault codes, providing only the system and subsystem number, and could not be used for detailed evaluation of fault isolation manual effectiveness (Silva, 1990:10).

Analysis of the fault reporting data indicated:

1. In 42 cases, analysts agreed with the actions taken by the maintenance technicians. In three of these cases, no troubleshooting tree in the FI manual was available that actually fixed the aircraft (Silva, 1990:11).

2. In 10 cases, although technicians reported using troubleshooting trees found in the FI manuals, analysts "could not find any FI troubleshooting tree which led to the documented corrective action which actually cleared the discrepancy" (Silva, 1990:13).

3. In 10 cases, technicians reported using the FI manuals but the manuals did not provide troubleshooting trees. Analysts "found the corrective actions were indeed possible outcomes of the troubleshooting trees per the given fault reporting codes" (Silva, 1990:13).

4. The remaining 47 cases could not be specifically analyzed for FI manual effectiveness. Reasons for this were inadequate documentation, lack of equipment or time, cannot duplicate discrepancies, and inadequate detail in the fault reporting code (Silva, 1990:13-14).

Because of the low number of usable discrepancies for analysis, 30.53 percent, it was "impossible to draw any sound conclusions" (Silva, 1990:17). It was noted that:

> a significant improvement in the recording of fault codes was seen throughout all of the inflight and maintenance discrepancies. This however, did not always give the technician the ability to accurately fault isolate or troubleshoot because of the consistent use of general fault reporting codes in identifying aircraft malfunctions. (Silva, 1990:17)

<u>The Present</u>

<u>1985 Chenzoff</u>. In the report <u>Maintenance Job Aids in the U.S. Navy: Present Status and Future Directions</u>, Chenzoff summarizes several electronic maintenance aids.

<u>Navy On-Board Maintenance Aiding Device (NOMAD)</u>. This is a prototype microcomputer based maintenance performance aid which was field tested from February 1982 to July 1983. NOMAD "uses a structured, automated diagnostic strategy which prompts and leads the technician through the appropriate procedures in troubleshooting and repair" (Chenzoff and Joyce, 25). The ease of which its software could be created and revised is considered its greatest contribution to performance aid technology (Chenzoff and

Joyce, 26). The software allowed technicians to annotate a note in the program if the instructions were inadequate, inaccurate, or could be stated a better way. This note could then be used by subsequent users for reference. This information could also be used later during system updating by software programmers to detect any flaws in the troubleshooting strategy (Chenzoff and Joyce, 26). Evaluation revealed that NOMAD could isolate faults in one-third the time and reduced Mean-Time-To-Repair by half (Chenzoff and Joyce, 26). As of the writing of this document, continued testing was on hold for funding.

Personal Electronic Aid for Maintenance (PEAM). PEAM is a tri-service project with the Navy as the lead service. Its objective is "to improve the productivity of organizational-level maintenance technicians by enhancing the quality, management, and delivery of technical information" (Chenzoff and Joyce, 27). The proposed device has six functional characteristics. They were:

> 1) It should be self contained (i.e., function without any external communication or power link;
> 2) It should be as small and light as is technically possible; at a minimum it must be hand portable;
> 3) It should provide simultaneous text and graphics whose quality is equal to paper based technical manuals;
> 4) It should be easy to use (e.g., cross references should be transparent), and should not require any typing skills (i.e., minimize keyed inputs);
> 5) The information should be accessible at any one of several levels of detail, at the option of the user;
> 6) It should be rugged and able to function at whatever time and place organizational level maintenance must be performed. (Hartung, 1028)

While considered to have several advantages over paper based systems, it involves some high risk technologies and has yet to be evaluated (Chenzoff and Joyce, 28).

Voice Interactive Maintenance Aided Device (VIMAD). VIMAD is a portable maintenance aid which presents the information for the job through the use a one-inch television tube providing a picture to the technician's right eye. This picture appears to be approximately 6 x 8 inches in size to the user (Chenzoff and Joyce, 30). The technician controls the presentation through a limited vocabulary recognition system or an auxiliary keypad. Video displays are motion pictures or still frames of where the technician is working. Verbal instructions for task accomplishment are provided by VIMAD with a built-in test of whether the technician is knowledgeable on the task. If not, the system explains the procedure in detail (Chenzoff and Joyce, 29). The systems major drawback are the videodiscs. They are expensive to produce which creates a problem for updating the maintenance information presented (Chenzoff and Joyce, 30). Continued refinement of the system was in work at the time of this article.

1987 Thomas. In the report, Computer-Based Maintenance Aids for Technicians: Project Final Report, Dr. Donald L.

Thomas and 1st Lieutenant Jeffery Clay summarize an AFHRL research and development effort started in 1976. The program objective was to:

> ...develop a prototype computer-based technical data system to facilitate the productivity of Air Force maintenance personnel. The system will provide information at the work site to guide technicians' performance. Attention will be given to determining the basic needs of technicians for information and the characteristics of a hardware and software system to provide that information... (Thomas and Clay, i).

The report outlines the results of a laboratory demonstration, two prototype systems for intermediate level maintenance and a prototype system for on-equipment maintenance (Thomas and Clay, 1). Only the prototype systems will be discussed in detail.

The first prototype, Computer-based Maintenance Aids System I (CMAS I), was developed with emphasis on "developing human factors and data presentation requirements" (Thomas and Clay, 5). The technical data in the CMAS I system had three levels of detail:

> Track 3. This track is intended for the novice technician. It is assumed he is not familiar with the specific system component or their location and, therefore, requires assistance in locating them. Also, he is unfamiliar with the procedures required to perform specific tasks.
> Track 2. This track is designed for the journeyman technician. The journeyman is described as a fully qualified 5-skill-level technician with at least 6 months of experience on the system. The journeyman is thoroughly familiar with the system and has accomplished most commonly performed tasks on the system at least a few times.
> Track 1. This track is designed for use by the "expert." The expert is described as a technician with extensive experience on the system being maintained,

> and extensive knowledge of the system and how it operates. He is able to perform most tasks with only limited technical data to remind him of critical actions or needs only specific information such as tolerances. (Thomas and Clay, 38-39)

The CMAS I prototype was installed at Offut AFB in an intermediate level radar maintenance shop. Problems encountered during this evaluation included: 1) the system required more shop space than anticipated, 2) the computer hardware generated more heat than expected, 3) the system was unreliable, i.e., it frequently froze forcing reinitialization of the system and loss of any work in process, 4) slow data response times, and 5) excessive technical data errors (Thomas and Clay, 80).

Building on the results of the CMAS I evaluation, the second prototype, CMAS II, was developed. Its objectives were to ensure that it "(a) did not have the limitations of CMAS I, (b) would be well accepted by the user, and (c) incorporated features which were practical for an operational system" (Thomas and Clay, 93). The field evaluation of CMAS II was done at Grissom AFB in an intermediate level radar shop whose responsibility was maintaining the AN/APX-64 radar system. The positive comments about the system included: 1) computer response time was considered good, 2) graphics were as good as those in the TO, 3) the system was easy to use, 4) procedures for locating and accessing data was considered effective, 5) the illustrated parts breakdown information was seen as a time saver, 6) because the computer forced the technician to read every step, it was felt that this lessened the chance of making a mistake, and 7) the troubleshooting capability of the system was considered a valuable tool. The primary criticism of the system was the schematic presentation. Technicians felt handicapped by the inability to see the whole diagram at one time. Other concerns with the system were the use of the direct access mode bypassed any critical warnings, notes or cautions and the use of the track system could allow the experienced technician to miss a critical step (Thomas and Clay, 110-112).

The third prototype system was a portable computer based maintenance aid system or PCMAS. Its objective was to "extend the technology for flightline maintenance and to develop the requirements for an operational automated technical data presentation system" (Thomas and Clay, 119). The scope of PCMAS included aircraft battle damage assessment (ABDA), automated diagnostics for on-aircraft maintenance, and integration of maintenance information systems (Thomas and Clay, 119). Although software and hardware have been acquired, full funding for this effort is not available. Planned efforts include ABDA for a damaged F-4 aircraft, testing of diagnostic algorithms for two or more F-16 subsystems, and testing of diagnostic algorithms on the A/F-18, an aircraft considered to have more sophisticated electronics and self-test capability than the F-16 (Thomas and Clay, 126-128).

1987 Nugent. Using the CMAS II system described under Thomas, 1987, the objective of this Navy sponsored study was to "compare the troubleshooting performance of military technicians who obtained information from conventional, paper-based maintenance manuals and from electronic devices" (Nugent and others, 1). Four troubleshooting tasks were accomplished by 36 technicians, 12 Air Force, 12 Marine, and 12 Navy, on a radio transmitter/receiver. The technicians were divided equally into two groups. One group had less than one year of equipment experience and the other group had more than one year of equipment experience (Nugent and others, 4). The seven hypotheses tested by this study all dealt with whether the electronic presentation system was more effective than technical manuals and how the use of the different systems, electronic versus paper, was affected by the technicians experience level (Nugent and others, 6).

For the hypotheses relating to electronic aiding, the results indicated that technicians took less than half the time to isolate faulted cards even though more tests were accomplished during the fault isolation process (Nugent and others, 11). For the hypotheses relating to technician experience level and electronic aiding or technical manuals, the experience level failed to account for any appreciable variance in the outcome measures (Nugent and others, 11).

When the technicians were surveyed and interviewed about their use of the electronic aid, they indicated that it was an acceptable alternative to paper-based maintenance manuals. The technicians one criticism of the electronic aid was the inadequacy of the schematic presentation on the computer display screen (Nugent and others, 12).

The Future

"The printed technical order (TO) as we know it today will become an anachronism in the future" (Genet, 56). Because of this, the future of maintenance aiding for the detection of equipment failures seems to lie in the area of artificial intelligence (Dierker and others, 37). All areas of artificial intelligence (AI), Expert Systems (ES), Natural Language Systems, Speech Recognition Systems, 3D or Stereoscopic-vision Systems, Intelligent Robots, and Neural Networks, have a potential role in maintenance aiding. It is the ES field that currently has the most potential for implementation into maintenance aiding (Dierker and others, 40; J. Richardson, 205). As has been seen, maintenance aiding is a data-intensive activity involving complicated decisions and expert systems have been identified as a logical system to apply to such activities (Allen, xiv).

How ES can be implemented in maintenance aiding is graphically depicted by Keller in his report <u>Human Troubleshooting in Electronics: Implications for Intelligence Maintenance Aids</u>. In his depiction provided in Figure 1, he sees applications of ES to maintenance in the areas of training and aiding. In the area of training, Keller states that any intelligent aid to training should not be limited to providing only one troubleshooting strategy. It should approximate the human troubleshooting process and therefore should support a range of different

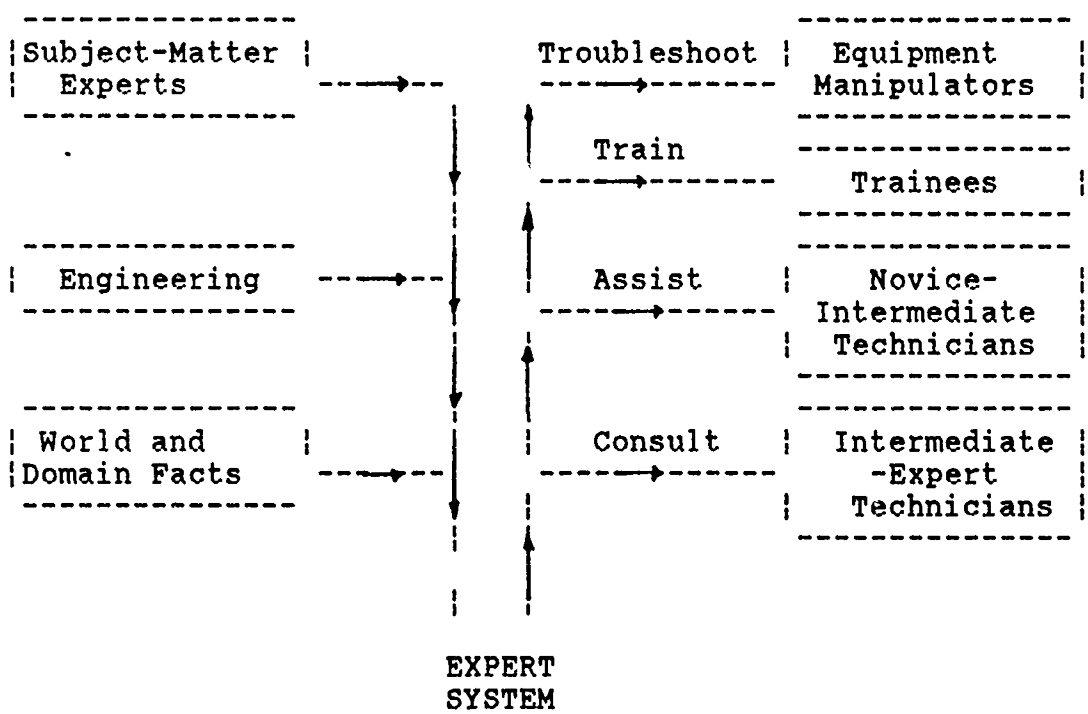

Figure 1. Human-system Interface for Development of Expert Systems. (Keller, 13)

approaches as long as there is instructional value in the approach (Keller, 14). For aiding, Keller identifies the need of the intelligent aid to be flexible. This is because the technician could be in a supporting role:

> acting primarily as a sensor and equipment manipulator under the direction of the intelligent aid. For complex problems, the technician is likely to have a more responsible part and use the aid as a consultant, bookkeeper, or reference tool. (Keller, 14)

There are some significant limitations in the application of AI to the maintenance aiding field. First, "no general expert system data bases have been built within the diagnostics domain; only small, single customer systems have been devised" (Dierker and others, 40). This means that there are significant technical difficulties to overcome before the development of a successful ES maintenance aid. The second difficulty is the development and cost of the rule base on which an ES depends (Dierker and others, 40). Rule based systems depend upon the knowledge of experts on the system. An expert is developed "through working in the field for an extended period of time and through experience accumulates knowledge and a "gut feel" for specific problems" (Antonelli, 451). For new systems, there is no knowledge to collect as there are no experts in the system. Because of this, the rule base could be completely dependent upon the knowledge of the system developers. Putting this knowledge into a rule base system is compounded by the situation where:

> as equipment sophistication increases, even the designer cannot accurately predict all the potential malfunctions and causes; a situation which is increasingly the case for computer circuits designed by computers. (Rasmussen, 612)

Because the rule base is the foundation of any ES, its accuracy and completeness are critical. As such, the development of this base has become the most significant cost in developing an ES (Dierker and others, 40).

A third concern is the amount of resources necessary to develop an ES and the estimates for the effort vary. On the low side is a self-repairing digital flight control system estimated to have taken 4 man-years to write 1200 rules. On the high side is the ES known as MYCIN, a medical diagnosis expert system. This ES is estimated to have consumed 50 man-years of senior medical personnel time (Dierker and others, 41).

Summary

A review of the literature pertaining to Air Force maintenance technical data indicates that there have been attempts to improve technical data since at least 1954. The development of proceduralized job guides was a significant improvement over the conventional TOs and have gained acceptance at all levels in the maintenance organization. However, subsequent research indicates that even these proceduralized guides have deficiencies. These deficiencies include, but are not limited to, low user acceptance, perceptions that the manuals are inaccurate, the inability of the manuals to be useful for all malfunctions, and poor troubleshooting logic resulting in wasted time.

Current and future trends for maintenance aiding are moving away from paper based aids into the area of automation. All current research is directed at providing a separate stand alone maintenance aid for use by the technician during troubleshooting. Future trends are in the area of developing AI systems for use as maintenance aids. The most promising AI field is that of ES but there are some significant technological hurdles yet to be overcome.

Since the 1980s and the move to develop electronic maintenance aids, there has not been an in-depth study to evaluate maintenance technicians' attitudes towards paper based maintenance aids. This provides additional support for the need to perform research into whether the FIMs are useful and accurate.

Additional references on the topics of troubleshooting and JPAs are provided in Appendix O.

III. Methodology

Overview

This chapter describes the methodology used to evaluate the hypotheses presented in Chapter I. Specifically, this chapter describes the population to be surveyed, justification for use of a survey instrument, the survey instrument itself and its reliability and validity. This chapter also describes the data collection plan and explains which statistical tests are used on the data.

Population

This study seeks the opinions of the maintenance technicians in base level aircraft maintenance organizations who use the F-16 Fault Isolation Manuals in the performance of their duties. Specifically, the study surveys personnel who are:

1. active duty aircraft maintenance technicians assigned to one of the six F-16 bases in the continental United States (CONUS),

2. in the grades E-1 through E-9, and

3. assigned to one of the AFSCs in Table 1.

These technicians are the personnel who use FIMs in their day-to-day duties. Their opinions should give an in-depth look at how well the FIMs are perceived as being useful and accurate in the isolation and correction of identified faults in the F-16.

Table 1. AFSCs Used in the F-16 FIM Survey

AFSC	Job Description
452X2A	Attack Control System Technician
452X2B	Instrument and Flight Control Systems Technician
452X2C	Communication, Navigation, Penetration Aids Technician
45272	Advance Level F-16 Avionics Technician
452X4B	Tactical Aircraft Maintenance Technician
452X5	Tactical Electrical and Environmental Systems Technician
462X0	Aircraft Armament Systems Technician

Justification for Survey

There are several reasons why the survey approach was chosen for this research problem. First, there are no data currently available for analysis of this problem. As noted in the introduction, the three previous studies by Mussari and Gemas were limited in depth and scope. Second, due to time and fiscal constraints, this problem did not lend itself to experimentation (see Section V for a recommendation on experimentation). Finally, in the Handbook of Research Design and Social Measurement, Miller identifies eight reasons for using a survey over other methods of gathering data:

1. Permits wide coverage for minimum expense both in money and effort.
2. Affords wider geographic contact.
3. Reaches people who are difficult to locate and interview.
4. Greater coverage may yield greater validity through larger and more representative samples.
5. Permits more considered answers.
6. Greater uniformity in the manner in which questions are posed.

7. Gives respondents a sense of privacy.
8. Lessens interviewer effect. (D. Miller, 98)

Each of these elements, along with the first two reasons, makes the use of a survey the most useful, expedient, and in-depth method available for completing this study.

The Survey Instrument

The survey instrument used to measure maintenance technicians' opinions about the usefulness and accuracy of FIMs was developed by AFHRL in their 1975 study on conventional TOs. It was also used in two subsequent studies by Bialek and Richardson in 1978. These studies are summarized in Chapter II.

The survey instrument used in this research contains three parts and can be found in Appendix A. Part I contains nine multiple choice background questions to obtain demographic information about the respondents. In addition to the demographic variables of skill level, grade, AFSC, and base, this study adds five additional variables: education level, type of FIM training received, aircraft maintenance experience, aircraft (F-16) experience, and FIM experience. Part II has 34 questions assessing the technicians' perceptions on the usability and accuracy of the various elements of the FIM. The FIM elements are illustrations, procedures, fault trees, troubleshooting logic, and indexes. Part III consists of seven questions. Six of the questions are multiple choice and solicit specific opinions about the FIMs. These questions include how much the technician uses the FIM, the most and least useful areas of the FIM, how FIM errors are reported, what element of the FIM would most improve the technician's use of the FIM, and what other methods do technicians use to isolate faults. The seventh question is an open-ended question allowing technicians the opportunity to express additional opinions about FIMs.

The ability to quantify the responses in part II is important in testing the hypotheses. For this purpose, a five point Likert Scale is used for measurement (Emory, 255), as in Figure 2.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE

[1]-----------[2]----------[3]---------[4]---------[5]

The fault isolation manuals I use are completely satisfactory.

Figure 2: Likert Measurement Scale Used in Survey

Although it has been determined that no erosion of results will occur when using the term <u>undecided</u> instead of the term <u>neutral</u>, it has been suggested that the term <u>neutral</u> seems less ambiguous whenever a midpoint is used (Armstrong, 362). As such, the term <u>neutral</u> was used in the survey instrument.

<u>Survey Validity</u>. There are two primary types of validity to consider when evaluating a measurement tool. Internal validity is "the ability of a research instrument

to measure what it is purported to measure" (Emory, 94). External validity is whether the research findings can be "generalized across persons, settings, and times" (Emory, 94).

Internal Validity. The internal validity, more specifically the content validity, of the survey instrument should be high. "Content validity of a measuring instrument is the extent to which it provides adequate coverage of the topic under study" (Emory, 95). Since the instrument has been used in three previous studies, 1975 AFHRL study, 1978 Richardson study, and 1978 Bialek study, it is a reasonable assumption that the instrument measures the topic under study, specifically attitudes of maintenance technicians towards TOs. Another method of determining content validity "is to use a panel of persons to judge how well the instrument meets the standards" (Emory, 95). Several reviews of the instrument were accomplished by various personnel and organizations to ensure the instrument's content validity.

For each review, those questions found to be ambiguous, hard to understand, or inconsistent, were either revised or replaced. First, the instrument was critiqued by logistics and management professors in the Department of Communication and Organizational Sciences and the Department of Logistics Management, School of Systems and Logistics. Second, eleven graduate students whose previous jobs were as aircraft maintenance officers, several of whom had been assigned to F-16 wings, were selected to critique the survey. Both critiques resulted in only minor changes to the instrument. Third, reviews were conducted by personnel from the Air Force Logistics Management Center (AFLMC), Gunter AFS, AL, sponsors of the study, and the Air Force Military Personnel Center (AFMPC), who sanction all official Air Force surveys. Again, only minor changes resulted from these reviews. Fourth, enlisted F-16 maintenance personnel assigned to the F-16 System Program Office at Wright-Patterson Air Force Base completed the survey. They represented three of the seven AFSCs of interest in the study. After completion, an in-depth review of the questions was done which resulted in minor changes to some questions and the addition of question 47. Fifth, to ensure the intent of the survey had not changed significantly from its original form, the survey was reviewed by Dr. Thomas of the Air Force Human Resources Laboratory (AFHRL). He was the coordinator for the 1975 AFHRL study and had reviewed subsequent changes to the survey for studies by Richardson and Bialek. His review resulted in minor changes to the instrument and the addition of two questions, questions 12 and 13. This was not so much an addition as it was an improved way of capturing the perceived usefulness and accuracy of FIMs by less experienced versus more experienced technicians. Finally, a pre-test of the questionnaire was accomplished by 14 F-16 maintenance technicians assigned to the 3246 Test Wing, Eglin Air Force Base, Florida. The respondents were encouraged to write comments on the questionnaire when available responses were inadequate or the question unclear. They were also asked to suggest any additional areas in which they felt the FIMs were inadequate which were not addressed by the instrument. Their responses provided no new additions or changes to the instrument.

External Validity. The results of the survey should be generalizable across the Air Force for FIM users within the AFSCs surveyed. As noted by Miller, "greater coverage may yield greater validity through larger and more representative samples" (D. Miller, 98), i.e., larger samples can improve external validity. In this study, the number of surveys sent out was 480. Using the sample size formula presented in the Data Collection Plan section, increasing the value of N, population size, by a factor of 8 to 40000, only increases the value of n, sample size, to 380 compared to the 358 computed. This larger sample size should improve the external validity of the study. Also, the sample is a complete representation of the AFSCs in the Air Force who use FIMs on the F-16 and represents 55 percent of the air force bases with the AFSCs who perform maintenance on the F-16.

Survey Reliability. The concept of reliability for the instrument can be considered as "the degree to which it supplies consistent results" (Emory, 98). As noted by Fink, simply by using a survey, reliability is improved. Specifically she states:

> The overwhelming majority of surveys rely on multiple choice or closed-ended questions because they have proven themselves to be more efficient and ultimately more reliable. Also, their reliability is enhanced because of the uniform data they provide since everyone responds in terms of the same options. (Fink and Kosecoff, 26)

However, using a survey does not ensure reliability. There are other factors to consider. One of these is that a respondent may "misunderstand the meaning of an item" (Bohrnstedt, 85). The method used to control this factor is to ensure the readability of the questions is at a level that is not too complex or sophisticated for the target population. To accomplish this, the survey instrument was evaluated using the software program Gram-mat-ik IV (Grammatik, 1989). This program evaluated the readability of the survey using two readability measures: Flesch-Kincaid and Flesch Reading Ease. The Flesch-Kincaid measure shows the instrument is written at an 8th grade level. "A readability score of between 8th-10th grade is considered most effective" (Grammatik, 6-3). The Flesch Reading Ease measure resulted in a score of 51. This score indicates a reading level requiring some high school level reading ability (Grammatik, 6-4). Since the United States Air Force has and continues to recruit high school graduates to be members of its enlisted forces (Ferkinhoff, 1; Johnson and

Reel, 38), it can be implied that there is an increased probability that personnel taking the survey comprehend and understand the questions in the same manner, thereby providing consistent results.

Another method of determining the reliability of an instrument is through the measurement of equivalence. This method is concerned with whether the items on an instrument which purpo~t to measure the same thing, are in fact measuring the same underlying attitude (Bohrnstedt, 86). One method of determining equivalence is through the use of Cronbach's coefficient alpha. This analysis was accomplished using a Cronbach Coefficient Alpha program developed to run on the Statistical Analysis Software (SAS) system. Results are reported in Chapter IV.

Data Collection Plan

As of January 31, 1990, the number of personnel assigned to the described population was 5,107. Using the formula in Figure 3, the minimum sample size is calculated to be 358. Dividing 358 by five, the original number of bases in the sample population [Note: A sixth base was later added as discussed below], results in 71 personnel per base to be surveyed. This simple division is possible because each base has approximately the same distribution per AFSC.

$$n = \frac{N (z^2) [p (1-p)]}{(N-1) (d^2) + (z^2) [p (1-p)]}$$

where:

n = Sample size
N = Population size (5107 estimate)
p = Maximum sample size factor (0.50)
d = Desired tolerance (0.05)
z = factor of assurance (1.96) for 95% confidence level (Department of the Air Force, 1974:12)

Figure 3. Minimum Sample Size Calculation Formula

Distributions by AFSC for 71 personnel is calculated as follows:

1. Determine the overall number of personnel for each AFSC.

2. Calculate the percentage of the total population (5107) the AFSC represents.

3. Multiply the value in step 2 by 71, the number of personnel to be surveyed per base. This gives the minimum number of personnel to be surveyed at each base for each AFSC.

The results of these calculations and the distribution by AFSC are provided in Table 2. Headquarters Tactical Air Command provided a sixth base for the sample population after completion of these calculations. The same number of surveys were sent to that base as determined by the preceding calculations. With this addition, a total of 480 surveys were sent, exceeding the minimum number of surveys required.

Table 2. Survey Distribution for Each Base

AFSC	Overall Number of Personnel Assigned by AFSC	Percentage of Total	Minimum Number Personnel for Survey per Base
452X2A	208	.04	3
452X2B	194	.04	3
452X2C	207	.04	3
452X2	80	.02	1
452X4B	2497	.49	35
452X5	382	.07	5
462X0	1539	.30	21
TOTALS	5107		71*

*An additional 9 surveys were sent to each base to account for any lost or damaged in transit or during testing.

Eighty surveys were distributed to maintenance technicians by a project officer assigned at each of the CONUS bases. Distribution instructions identified the requirement that for each AFSC, a representative sample of the skill levels at their wing was needed to complete the survey. For instance, in AFSC 452X4B, if the skill level distribution is 40% 3-levels, 40% 5-levels, and 20% 7-levels, survey distribution by skill level would be 14, 14, and 7 respectively.

The data collection method is a purposive, frequency controlled sampling method based on a quota, hence the distribution of the survey to the AFSCs shown in Table 2 (Emory, 280). A quota sample is used to ensure that "the sample is representative of the population from which it is drawn" (Emory, 281). When more than three dimensions are used, in this case the seven AFSCs and the three different skill levels, then a frequency control system should be used (Emory, 282). The use of a frequency control system for AFSCs and skill levels in the data collection method should eliminate distortions due to a nonrepresentative distribution of AFSC and skill level.

Though the quota sampling method is frequently used, several weaknesses are associated with it. These are:

> 1. The idea that quotas on some variables assume representativeness on others is an argument by analogy. It gives no real assurance that the sample is representative on the variables being studied.
> 2. The data used to provide controls may be out of date.
> 3. There is a practical limit on the number of simultaneous controls that can be applied so that the quota may not be precise enough.
> 4. The choice of subjects is left to field workers to make on a judgmental basis. They may choose only friendly looking people [or] people who are convenient to them. (Emory, 282)

In this research, each of these weaknesses is controlled. For item one, the population to be sampled includes all AFSCs who use FIMs on the F-16 in the accomplishment of their duties. The sample is also taken from a population that represents 55 percent of the Air Force F-16 bases. For item two, the data used to determine the sample were current as of January 1990, only three months prior to survey distribution. For item three, only two control elements are used, AFSC and skill level. This limited number of control elements should not adversely impact the precision. Finally, on item four, though the survey distribution is being performed by air base personnel, the sample size of 71 should eliminate the possibility of having only friends or personnel who are conveniently accessible take the survey.

Project officers at each wing were responsible for the distribution and collection of surveys. This is not the most preferred approach due to possible introduction of unnecessary variables influencing the test. However, it is anticipated that the introduction, if any, of unnecessary variables to the responses is minor. The decision to use project officers to administer the questionnaires, instead of the researcher, was made because of time limitations imposed by the academic environment and the lack of TDY funds.

Data Classification

The information collected contained nominal and ordinal levels of data, depending on the type of question. The nominal data collected included AFSC, base of assignment, training received on FIMs, the most useful features of FIMs, the least useful feature of FIMs, FIM error reporting, what would most improve the technician's use of the FIM, and other methods used beside FIMs. Ordinal data were collected on the questions regarding military rank, skill level, education, aircraft maintenance experience, F-16 experience, F-16 FIM experience, and FIM use. Responses to the opinion questions in Part II of the survey were considered ordinal data since they were based on the five point Likert Scale. There are differing ideas about whether or not data based on a Likert Scale are interval data. In the text, Business Research Methods, Emory states "the Likert Scale is ordinal only" (Emory, 258). For this research effort, the data gathered with the Likert Scale are assumed to be ordinal.

Data Analysis

The following discussion covers the statistical techniques used for the data analysis to support the research hypotheses discussed in Chapter I. All analyses are accomplished using the Statistical Analysis Software (SAS) system.

Frequencies. The PROC FREQ procedure in SAS provides descriptive statistics for the responses to all the survey questions. For the nominal data, the number of personnel that responded to each category are presented. For ordinal data, the number of observations, the minimum and maximum values, and the mean and standard deviation for each question are presented.

Pearson Correlation Coefficients. The Pearson Correlation test is applied to the hypotheses associated with Research Question 1 using the PROC CORR procedure in

SAS. These coefficients measure the strength of relationships between two variables. In the text Research Methods in Social Relations, Kidder discusses interpreting correlation coefficients and states "It is one measure of association between two variables and ranges from 0 (no relationship) to +1.0 (perfect relationship) or -1.0 (perfect negative relationship)" (Kidder, 329). Kidder offered the guidelines in Table 3 for interpretation of the relationship.

Table 3. Interpreting Correlation Coefficient Relationships

Correlation Coefficient |r|	Strength of Relationship
> .70	Very Strong
.50 - .69	Strong
.30 - .49	Moderate
.15 - .29	Weak
< .15	Not Much

(Kidder, 329)

These values can be positively or negatively correlated and will be used in interpreting the correlations accomplished for this research.

Research Question 1. This research question concerns whether there is a relationship between the maintenance technician's perceptions of FIM usefulness and accuracy and their use of the FIM. The Research Hypotheses 1.1 and 1.2 propose that a positive correlation exists between the maintenance technician's perceptions of usefulness and accuracy of the FIM elements and their use of the FIM. For example, the survey collects information on the accuracy of the fault trees through survey questions 29 and 30. The Likert Scale responses of these questions are combined in SAS providing a cumulative response to the maintenance technician's perceptions on the accuracy of the FIM fault trees. These results are then used in determining the correlation coefficient for use in evaluating Research Hypothesis 1.2. Table 4 identifies the elements of the FIM and the questions measuring the technician's perceptions of the accuracy or usefulness of that element.

Table 4. FIM Elements and Related Survey Questions

Element Measured	Survey Question
General FIM Accuracy	Questions 11 and 16
Illustration Usefulness	Questions 17 and 21
Illustration Accuracy	Questions 20 and 23
Procedures Usefulness	Questions 25 and 26
Procedures Accuracy	Questions 23 and 24
Fault Tree Usefulness	Questions 27 and 28
Fault Tree Accuracy	Questions 29 and 30
FIM Usefulness in Troubleshooting	Questions 31 and 34
FIM Accuracy in Troubleshooting	Questions 32 and 33
Index Usefulness	Question 35
Index Accuracy	Question 36
Fault Code Accuracy	Questions 38 and 39
FIM Usefulness in Training	Questions 12,13,14, and 15

It must be noted that correlation is not justification for implying causation. While it is possible that there is an underlying causal relation, any strong correlation could be the result of other factors not under study (Schlotzhauer and Littell, 260).

Normality. An important consideration in the analysis of data is to determine whether the data are normally distributed. The result of this step determines whether parametric or non-parametric analysis methods are appropriate. Although Blalock suggests "that whenever N is greater than or equal to 100, the normality assumption can practically always be relaxed" (Blalock, 142), a normality test is done on the data for the Likert Scale responses. For this test, all Likert Scale data are combined using SAS into one variable and the PROC UNIVARIATE procedure is used. The PROC UNIVARIATE procedure performs a Shapiro-Wilk normality test and produces a normality plot (Schlotzhauer and Littell, 119).

Analysis of Variance (ANOVA). The ANOVA statistical test is used for testing hypotheses associated with Research Questions 2, 3, 4, and 5. The PROC ANOVA procedure in SAS is useful in determining whether differences between groups exist and, if so, whether they are statistically significant (Schlotzhauer and Littell, 219). The Scheffe means test is used with the SAS ANOVA procedure to determine any difference in means. This is because the ANOVA F-test "tells you if the means are significantly different from each other, but it does not tell you which means differ from which other means" (SAS, 470). The selection of the Scheffe method of means testing was selected for two reasons. First, the Scheffe test "never declares a contrast significantly different if the overall F test is nonsignificant" (SAS, 473). Second, the Scheffe means test can "be more powerful than the Bonferroni or Sidak methods if the number of comparisons is large relative to the number of means" (SAS, 473). The research hypotheses identified in Chapter I can result in as many as seven means being compared six ways, or 42 comparisons.

Research Question 2. This question concerns whether differences exist by demographic factor as to the use of the FIM by maintenance technicians. Use of the FIM is measured by the technicians' responses to question 45 of the survey. The Research Hypothesis 2.1 is a null hypothesis that states the different demographic factors of grade, AFSC, skill, base of assignment, aircraft maintenance experience, F-16 experience, and FIM experience, make no difference in the extent of use of the FIM, i.e., the mean for FIM use of each demographic factor will be equal. The alternate hypothesis states that the means of the different demographic factors are not equal. SAS tests the hypothesis by "partitioning the total variation in the data into variation due to differences between groups and variations due to error" (Schlotzhauer and Littell, 220). This error does not refer to error in the data but to any kind of natural variation that can occur as a result of other variables not under consideration (Schlotzhauer and Littell, 220).

Research Question 3. This question concerns whether differences by demographic factors exist as to the maintenance technician's perceptions of FIM usefulness and accuracy. Research Hypotheses 3.1 and 3.2 are null hypotheses that state the means for the technician's perceived usefulness and accuracy by the different demographic factors will be the same. The alternate hypothesis is that the means of the groups will be different. For determining the FIM usefulness and accuracy, a step similar to what was done by SAS for the Pearson Correlation is accomplished here. SAS combines all the survey opinion questions relating to FIM usefulness (see Table 4) into a variable representing each technician's perception of FIM usefulness. SAS uses the combined variable mean to test for differences between the different demographic factor classes. A duplicate SAS program performs the same step for determining differences between the different demographic factors for the combined variable accuracy.

Research Question 4. This question concerns whether differences by level of FIM use exist as to the maintenance technician's perceptions of FIM usefulness or accuracy. Research Hypotheses 4.1 and 4.2 are null hypotheses that state the level of FIM use makes no difference in the maintenance technician's perceptions of FIM usefulness or accuracy. Here too, SAS combines the usefulness and accuracy questions into one usefulness and accuracy variable respectively and tests them against the reported FIM use level in question 45.

Research Question 5. This question investigates whether differences exist by demographic factor as to the maintenance technician's satisfaction with the FIM, as measured by survey Question 10. Research Hypothesis 5.1 is a null hypothesis that states the means for the technician's satisfaction are the same for the different classes of each demographic factor. The alternate hypothesis is that the means for the demographic factor classes will be different.

Assumptions

The following assumptions are made in this study.

1. The response to the survey questions permitted the technicians to adequately describe their perceptions of the FIMs.

2. Technician's responses to survey questions were honest.

3. The FIM's readability does not adversely affect the use of the TO by maintenance technicians.

4. Survey distribution reflects skill level manning at the different bases.

Limitations

The following limitations are associated with this study:

1. The use of project officers instead of the researcher could have affected the respondents' answers to the questionnaire.

2. Other demographic variables could have an effect on the maintenance technician's opinions about FIMs.

3. Collaboration between technicians during completion of the survey may have occurred thereby affecting the responses.

4. Other factors not under study could be influencing the perceptions of the maintenance technician about the FIM.

Summary

This chapter identified the population to be studied and the survey instrument, including justification for the use of a survey. After a discussion of the survey instrument's validity and reliability, the data classification and data collection plan for the study was identified. Finally, the different statistical techniques used in analyzing the data were addressed. The chapter concluded with the different assumptions and limitations thought to be relevant to this study.

IV. Analysis and Discussion

Overview

This chapter contains several analyses and discussions of results obtained from evaluation of the F-16 Fault Isolation Manual survey. The results of the SAS program determining the survey instrument's Cronbach's coefficient alpha is first presented and discussed. This is followed by a discussion on response frequencies for each survey question. The normality test results using SAS are then presented. A summary of the statistical tests, the Pearson Correlation Coefficients and ANOVA tests are then presented. Finally, the responses to the open ended question are summarized.

Cronbach's Coefficient Alpha

Table 5 provides the results of the SAS program testing the survey instrument for the Cronbach's Coefficient Alpha.

Table 5. F-16 Survey Cronbach's Coefficient Alpha Values

Survey Element	Coefficient Value
General FIM Accuracy	.7472698
Illustration Usefulness	.5239518
Illustration Accuracy	.5880175
Procedure Usefulness	.3326856
Procedure Accuracy	.8329961
Fault Tree Usefulness	.47543[illegible]7
Fault Tree Accuracy	.8520666
Troubleshooting Usefulness	-.132716
Troubleshooting Accuracy	.7438989
Fault Code Accuracy	.7940767

Interpretation of these values is similar to what is discussed for the Pearson Correlation Coefficients in Chapter III. The closer the value is to 1.0, the more likely it is that the questions relating to each survey element are homogenous, that is, they are measuring the same thing (Guilford, 485). Except for troubleshooting usefulness, the survey instrument is reliable for measuring the technicians' attitudes towards the FIM. The area of troubleshooting usefulness is further discussed under Pearson Correlation Coefficients later in this chapter.

Survey Response

A total of 480 surveys were mailed to project officers at Homestead, MacDill, Shaw, Moody, Luke and Hill AFBs. The project officer at each base distributed the surveys to personnel possessing the AFSCs identified in Chapter III. Three hundred seventy-five surveys were returned for a 78 percent return rate. Although enough surveys were returned to meet the requirements of the minimum sample size, 358, if the additional base had not been added to the sample, an insufficient number of surveys would have been received. As it is, with this response rate, the Cronbach Alpha results, and the steps to improve reliability and validity identified in Chapter III, the conclusions are considered generalizable to the Air Force F-16 population.

Survey Question Frequencies

A response summary, by section, of the survey instrument follows.

Demographic Results. The grades, AFSCs, and skill levels of technicians participating in the survey are presented in Figures 4, 5, and 6.

```
Grade                                                  Frequency  Percent
  E2   |*********                                           29      7.73
  E3   |****************                                    54     14.40
  E4   |********************************                   107     28.53
  E5   |***********************************                119     31.73
  E6   |***************                                     49     13.07
  E7   |****                                                16      4.27
  E8   |*                                                    1      0.27
       |
        -----+-----+-----+-----+-----+-----+
            20    40    60    80   100   120

                    Responses
```

Figure 4. Survey Response by Grade

```
 AFSC                                                   Frequency Percent
452X2A  |***                                                 16      4.27
452X2B  |*****                                               25      6.67
452X2C  |***                                                 18      4.80
45272   |*****                                               24      6.40
452X4B  |******************************                     151     40.27
452X5   |******                                              31      8.27
462X0   |**********************                             110     29.33
        |
         ---+---+---+---+---+---+---+---+
           20  40  60  80 100 120 140 160

                  Responses
```

Figure 5. Survey Response by AFSC

Review of the AFSC distributions indicate they approximate the required distributions identified in Chapter III. Table 6 is a comparison of this distribution.

Table 6. Comparison of Requested and Received AFSCs.

AFSC	Percent Requested	Percent Received
452X2A	4	4.28
452X2B	4	6.68
452X2C	4	4.81
45272	2	6.42
452X4B	49	40.37
452X5	7	8.29
462X0	30	29.14

Review of the Figure 6 data indicates that the number of three level technicians is lower than the projected three level manning discussed in Chapter I. Since each project officer was requested to distribute the surveys approximating the skill level distribution for their base, these results are considered valid.

```
Skill Level                                               Frequency  Percent

   3     |**********                                         49       13.07
   5     |********************************                  158       42.13
   7     |*********************************                 162       43.20
   9     |*                                                   6        1.60
         |
         |
          ---+---+---+---+---+---+---+---+
            20  40  60  80  100 120 140 160

                         Responses
```

Figure 6. Survey Response by Skill Level

The respondents' distributions by base are provided in Figure 7.

```
Base Responses                                           Frequency  Percent

Homestead |*************************                        63       16.80
Shaw      |****************************                     69       18.40
MacDill   |******************************                   76       20.27
Luke      |****************************                     70       18.67
Moody     |********************                             49       13.07
Hill      |*******************                              48       12.80
           ---+---+---+---+---+---+---+---+
             10  20  30  40  50  60  70  80

                      Responses
```

Figure 7. Survey Response by Base

In the area of education, 78 percent of the respondents reported having accomplished some post-high school education. Figure 8 provides the specific distributions.

```
Education level                                     Frequency  Percent

Non High School |*                                        1       0.27
High School     |********                                81      21.60
High School +   |**************************             260      69.33
Associates      |*                                       13       3.47
Associates +    |*                                       16       4.27
Bachelors       |*                                        4       1.07
                 ---+---+---+---+---+---+---+
                   40  80 120 160 200 240 280

                          Responses
```

Figure 8. Survey Response by Education Level

Figures 9, 10, and 11 identify the respondents' maintenance experience, F-16 experience, and FIM experience. Almost one-half the respondents have seven years or more maintenance experience. At the seven year point, a technician is authorized to become certified as a master maintenance technician within his/her AFSC and therefore should have the most knowledge of their systems.

```
Maintenance Experience                          Frequency Percent

< 1 year          |*******                           39      10.40
  1 year  <  2    |*****                             27       7.20
  2 years <  7    |************************** 130      34.67
  7 years < 12    |**********************       114      30.40
 12 years or more|*************                  65      17.33
                   ---+---+---+---+---+---+---+
                     20  40  60  80  100 120 140

                          Responses
```

Figure 9. Survey Response by Maintenance Experience

While almost one-half of the technicians have over 7 years maintenance experience, the F-16 experience distributions indicate that 81 percent of the respondents have less than 7 years F-16 experience.

```
F-16 Experience                                 Frequency Percent

< 1 year          |********                          58      15.47
  1 year  <  2    |*******                           54      14.40
  2 years <  7    |************************** 193      51.47
  7 years < 12    |********                          61      16.27
 12 years or more|*                                  9       2.40
                   ---+---+---+---+---+---+---+
                     30  60  90  120 150 180 210

                          Responses
```

Figure 10. Survey Response by F-16 Experience

Review of the FIM experience response distribution in Figure 11 indicates that 86 percent of the technicians have less than seven years FIM experience. This number corresponds closely to the percentages for F-16 experience. This low percentage can be attributed to two factors. First, FIMs as used on the F-16 today have only been in existence approximately 12 years. As such, it is probable that a lower number of technicians have remained in the Air Force and on the F-16 all this time. Second, inter-aircraft transfers of maintenance technicians do not frequently occur, and if they do, FIMs are currently in use on only the C-5, F-16, F-15, and B-1B (Air Force Studies Board, 72). Third, technicians responding to this question could have responded concerning only their F-16 FIM experience.

```
FIM Experience                                      Frequency Percent

< 1 year          |****************                     97      25.87
  1 year   <  2   |*********                            62      16.53
  2 years  <  7   |*************************           162      43.20
  7 years  < 12   |********                             50      13.33
 12 years or more |*                                     4       1.07
                   ---+---+---+---+---+---+---+
                    25  50  75 100 125 150 175

                          Responses
```

Figure 11. Survey Response by FIM Experience

Figure 12 provides the distributions for the type of FIM training the technicians have received. Less than one-third of the technicians, 30.93 percent, received FIM training during their initial technical training phase in the Air Training Command (ATC). Over three-fourths, 77.76 percent, received training through a Field Training Detachment (FTD). Almost 70 percent of the personnel have

```
FIM Training                                              Frequency  Percent

ATC Training    |***********                                  116     13.21
FTD Training    |*****************************                291     33.14
OJT             |*************************                    251     28.59
Contractor      |*                                             18      2.05
   Training     |
MAT             |**********                                   101     11.50
AMQP            |*********                                     92     10.48
Other           |*                                              9      1.03
                 ---+---+---+---+---+---+---+
                   40  80  120 160 200 240 280

                              Responses
```

Figure 12. Survey Response by FIM Training

received some sort of base level On-the-Job-Training (OJT). It must be noted that these responses are not mutually exclusive as each technician could have received training through any combination of choices.

FIM Element Opinions. Frequency response distribution plots and means for each opinion question are provided in Appendix B. FIM elements measured by more than one question, for instance the usefulness of fault trees which is measured by two questions, have a cumulative response reported if the question responses are similar. If apparent differences between question responses exist for that FIM element, then the statistics for each question are reported. Also, the question response categories of strongly disagree - disagree and strongly agree - agree are combined into a single disagree or agree category respectively.

General Information. Table 7 provides descriptive information for the opinion questions. Each category's mean, standard deviation, highest response and lowest response are provided. For the highest and lowest category, the question with that response is provided in parenthesis.

Table 7. FIM Opinion Response Descriptive Statistics

Response Category	Mean	Standard Deviation	Low	High
Strongly Disagree	4.92	3.76	0.27(27)	16.77(16)
Disagree	21.63	11.67	4.27(27)	39.73(16)
Neutral	40.78	6.79	22.93(12)	50.93(19)
Agree	29.22	15.58	8.00(16)	54.40(12)
Strongly Agree	3.48	3.80	0.00(39)	14.13(12)

It is interesting to note that on average, 40.78 percent of the respondents chose the neutral position for an opinion question. It can also be noted that for the low and high response categories, three questions occurred more than once. Question 27 addressing the issue of always following the fault trees for troubleshooting had the lowest rate for strongly disagree and disagree categories. Question 12 addressing whether FIMs were useful to new technicians assigned to the F-16 had the lowest neutral category response and the highest responses for the categories of agree and strongly agree. Question 16 addressing whether the FIMs always led to the correct isolation of a maintenance problem had the highest response rates in the strongly disagree and disagree categories.

FIM User Satisfaction. Question 10 measures the technicians' perceived satisfaction with their use of the manual. The results were almost evenly divided. Over 33 percent disagreed that the FIM used in their job was satisfactory while 28.54 percent agreed that the FIM was satisfactory.

FIM Accuracy. Questions 11 and 16 measure the technicians' perceptions on the FIMs' accuracy. The cumulative result of the two questions indicates that the majority of technicians, 51.47 percent, disagreed that the FIM.is an accurate source of information. Only 13 percent agreed that the FIM is an accurate source of information.

FIM Use by Technicians. Two questions, 12 and 13, measure the maintenance technicians' perceptions on whether the FIM is useful to new or experienced technicians assigned to the F-16. As such, each question is reported separately.

Question 12. Over 68 percent of the technicians perceive the FIM as useful for new technicians assigned to the F-16. A small percentage of technicians, 8.53 percent, reported disagreeing that the FIM is useful for new technicians.

Question 13. This question determines whether technicians perceived the FIM as being useful to experienced technicians assigned to the F-16. Over 63 percent reported agreeing that the FIM is useful to experienced technicians and 6.67 disagreed that the FIM is useful.

FIM Training. Two questions, 14 and 15, evaluate the technicians' perceptions on training and the FIM. The first, question 14, addresses the adequacy of training for FIM use and question 15 addresses whether the FIM is useful to technicians for on-the-job-training (OJT).

Question 14. In determining whether the training technicians received on the FIM is considered adequate, 52.8 percent of the respondents agreed. Only one-third as many technicians, 17.33 percent, disagreed that the training received had been adequate.

Question 15. In the area of OJT, 63 percent of the respondents agreed that the FIM is useful. Approximately 8 percent disagreed with the usefulness of the FIM as a training tool.

Illustrations. Six questions are dedicated to the evaluation of the FIM illustrations. In addition to two questions each on illustration usefulness, 17 and 21, and accuracy, 20 and 22, two additional questions are included. The first, question 18, addresses the maintenance technicians' perceptions on the need to have more illustrations in the FIM. The second, question 19, measures the technicians' perceptions on whether the size of the FIM illustrations is too small.

Illustration Usefulness. In determining the usefulness of the FIM illustrations, 30.67 percent perceived the FIM illustrations to be useful. Approximately 23 percent disagreed that the illustrations are useful.

Illustration Accuracy. Only 16 percent of the technicians agreed that the illustrations are accurate. More than twice as many technicians, 35.2 percent, disagreed that the illustrations are accurate.

More Illustrations. In determining whether the FIMs need more illustrations, 49 percent of the technicians agreed on the need for more illustrations. Only 6.66 percent disagreed that the FIM need more illustrations.

Illustration Size. Technicians are almost equally divided in their perceptions on whether the size of the FIM illustrations is too small to see details. Almost 26 percent disagreed that the illustrations are too small to see details and 23.2 percent agreed that FIM illustrations are too small to see details.

FIM Procedure Accuracy. Questions 23 and 24 of the survey measure the technician's perceptions on the accuracy of the FIM procedures. Question 23 measures FIM procedure accuracy for fault correction and question 24 measures FIM procedure accuracy for fault isolation. For the cumulative response, 14.27 percent agreed that the FIM procedures are accurate, while three times as many, 42.14 percent, disagreed that the procedures are accurate. Results indicate that respondents perceive the procedure accuracy for fault correction and fault isolation to be approximately the same. For accuracy in fault correction procedures, 43.47 percent disagreed that the FIMs are accurate while 12 percent agreed that the FIMs are accurate. For accuracy in fault isolation procedures, 40.8 percent disagreed that the FIM procedures are accurate, with 16.54 percent agreeing that the procedures are accurate.

FIM Procedure Usefulness. As with procedure accuracy, two questions, 25 and 26, are used to measure the technicians' perceptions of the usefulness of the FIM procedures. Because of significant differences in the agree/disagree results between the two questions, each question is addressed separately.

Question 25. This question determines the technician's perceptions on the ease of understanding the FIM procedures use. Only 10 percent reported disagreeing that the FIM procedures are easy to understand. Fifty-seven percent agreed that the FIM procedures are easy to understand.

Question 26. This question evaluates whether the FIM procedures provides all the necessary information to isolate faults. Over 37 percent disagreed that the FIM procedures are comprehensive in nature, while 18.9 percent agreed that the FIM provides all the necessary information.

FIM Fault Tree Usefulness. Two questions, 27 and 28, measure the technician's perceptions of fault tree usefulness. Only 11 percent disagreed that the FIM fault trees are useful, while 48.8 percent agreed that the FIM fault trees are useful.

FIM Fault Tree Accuracy. Two questions, 29 and 30, measure the technician's perceptions of fault tree accuracy. The results are almost exactly the opposite of those for fault tree usefulness. Only 11.34 percent agreed that the FIM fault trees are accurate while 44 percent disagreed that the FIM fault trees are accurate.

FIM Troubleshooting Usefulness. Two questions, 31 and 34, measure the technician's perceptions of the usefulness of the FIM troubleshooting logic. The response distributions for the two questions are significantly different. As such, each question's responses are presented.

Question 31. This question determines whether technicians perceived the FIM to be useful even if the fault is not identified in the FIM. Approximately 22 percent of the technicians disagreed. Over 37 percent of the technicians responded that they agreed the FIM is useful even if the fault is not specifically identified in the FIM.

Question 34. For this question, the survey tries to determine whether the FIM's troubleshooting logic takes too much time to use. Over 37 percent of the technicians disagreed that the FIM takes too much time to perform fault isolation. Only 16 percent of the technicians reported agreeing that the FIM takes too much time to perform fault isolation.

FIM Troubleshooting Accuracy. To evaluate the accuracy of the troubleshooting logic of the FIMs, two questions, 32 and 33, were asked. The individual question responses were very similar and therefore are reported as a cumulative distribution. Approximately 19 percent of the technicians disagreed that the FIM provides accurate troubleshooting instructions. Over 38 percent of the technicians agreed that the FIM provides accurate troubleshooting instructions.

FIM Index Usefulness. One question, 35, is used to determine the perceived usefulness of the FIM indexes. The majority of the technicians, 54.67 percent, agreed that the indexes are useful. Only 5.86 percent of the technicians disagreed that the index is useful.

FIM Index Accuracy. Here too, one question, 36, is used to determine the technicians' perceptions on the accuracy of the indexes. Forty-four percent of the technicians responded that they agreed that the indexes are accurate. Almost 11 percent disagreed that the indexes could be used accurately to locate the correct fault tree for a particular maintenance problem.

Fault Code. A key element of the fault isolation process is the fault code for a maintenance malfunction. Question 37 measures the technician's perception about receiving the fault code for a maintenance problem. Over 39 percent disagreed with the survey statement that the technicians always receive the fault code. Only 21 percent reported agreeing with the survey statement.

Fault Code Accuracy. Two questions, 38 and 39, measure the technician's perceptions on the accuracy of the fault codes. Though the responses to each question are similar, each is reported separately. Question 38 measures the technician's perceptions on the accuracy of the fault code to identify the subsystem with the fault. Question 39 measures the technician's perceptions on the accuracy of the fault code to correctly identify the fault. Cumulatively, 37.33 percent of the technicians disagreed on the accuracy of the fault codes while 18.13 percent agreed that the fault codes received are accurate.

Question 38. Over 34 percent of the maintenance technicians disagreed that the fault codes accurately identify the subsystem with the fault. Approximately 22 percent of the technicians reported agreeing that the fault codes accurately identify the subsystem with the fault.

Question 39. Forty percent of the maintenance technicians disagreed that the fault code they receive accurately identifies the fault. Only 13.87 percent of the technicians agreed that the fault code they receive accurately identifies the fault.

Specific FIM Use Questions. In Section III of the survey, specific opinions about FIM are solicited. These areas include the technician's perceptions on the following areas: how much they use the FIM, what is the best area of the FIM, what is the worst area of the FIM, what do they do when errors in the FIM are discovered, what area of the FIM they would improve, and what other methods do they use to perform fault isolation. The final question in this area is an open ended question which allows the technicians to express any additional opinions about their use of the FIMs.

The distributions for the maintenance technician's use of the FIM are provided in Figure 13. Approximately 58

```
Percent FIM Use                                     Frequency Percent

 0 - 25   |*********************                       132      35.20
26 - 50   |**************                               87      23.20
51 - 75   |**************                               87      23.20
75 - 100  |***********                                  69      18.13
           -----+-----+-----+-----+-----+
               10    20    30    40    50

                       Responses
```

Figure 13. Survey Response for FIM Use

percent of the technicians reported using the FIM less than 50 percent of the time for fault isolation. Over 46 percent of the technicians use the FIM 25 to 75 percent of the time, over one-third of the technicians use the manual 0 to 25 percent of the time, and less than 20 percent of the technicians use the manual 75 to 100 percent of the time. Distributions for FIM use by grade, AFSC, skill level, base, maintenance experience, F-16 experience, and FIM experience are provided in Appendix C. An interesting observation from these data is that for AFSC 452X2C, over 70 percent of the respondents report using the FIM 0 - 25 percent of the time.

Figure 14 provides the responses for the technicians' perceptions of the FIM's most useful feature. Two areas, fault trees and the step-by-step procedures, were rated the best. Because the technicians could only select one answer for the FIM's most useful area, the responses support the opinion responses in Section II. For fault trees, this result supports the opinion response for question 27 where

FIMs Most Useful Area		Frequency	Percent
Fault Trees	∣****************************	140	37.43
Simplicity	∣****	19	5.08
Step-by-Step Procedures	∣***************************	134	35.83
Illustrations	∣********	41	10.96
Indexes	∣**	11	2.94
Other	∣******	29	7.75
	---+---+---+---+---+---+---+ 20 40 60 80 100 120 140		

Responses

Figure 14. Survey Response for the FIM's Most Useful Area

57 percent of the technicians agreed that fault trees are useful in performing fault isolation. For step-by-step procedures, question 25 of the opinion questions indicated that over 57 percent of the technicians agreed that the FIM procedures are easy to understand. All other areas of the FIM received 11 percent or less of the responses. The percentages for most useful feature are also consistent across the demographic factors of grade, AFSC, skill level, base, maintenance experience, F-16 experience and FIM experience. The distributions for these demographic factors are in Appendix D. Two notable observations are that over 55 percent of the technicians with the 452X2C AFSC report fault trees as the most useful feature of the FIM and over 47 percent of the AFSC 452X4B technicians responded that the FIMs step-by-step procedures are the most useful feature.

Figure 15 provides the responses for the technicians' perceptions on the FIM's least useful area. While responses are not evenly distributed, no single area stands out as being less useful than another area. It is interesting to note that indexes has the largest percentage of responses as the FIMs least useful area. Examination of the opinion responses for the indexes indicate that 54.67 percent of the technicians agreed that the index is useful and 44 percent agreed that it is accurate. The distributions for grade,

```
FIMs Least Useful Area                           Frequency  Percent

Fault Trees     |**************                      47       12.60
Simplicity      |**********************              72       19.30
Step-by-Step    |***********                         38       10.19
  Procedures    |
Illustrations   |***********************             76       20.38
Indexes         |*************************           84       22.52
Other           |****************                    56       15.01
                 --+--+--+--+--+--+--+--+-
                  10 20 30 40 50 60 70 80

                        Responses
```

Figure 15. Survey Response for the FIMs Least Useful Area

AFSC, skill level, base, maintenance experience, F-16 experience, and FIM experience are presented in Appendix E. The most notable observation from review of these data are that over 41 percent of the technicians with the AFSC 452X2C consider indexes as the worst area of the FIM.

Figure 16 provides the responses as to how the technicians report errors found in the FIM. While reporting TO errors should be accomplished through the AFTO 22 reporting system, this response only received the second

```
FIM Error Reporting                            Frequency  Percent

Tell Supervisor |************************         118       31.55
AFTO 22         |*********************            104       27.81
Ignore the Error|********                          39       10.43
No Errors Seen  |****************                  81       21.66
Other           |******                            32        8.56
                 ---+---+---+---+---+---+
                   20  40  60  80  100 120

                        Responses
```

Figure 16. Survey Response for FIM Error Reporting

highest response. The highest response was to inform the individual's supervisor. It is possible that the supervisor initiated the AFTO 22 paperwork to report the error but this supposition can not be proven with these data. An interesting result is the response that over 21 percent of the technicians reported having seen no errors in the FIM. Assuming that no errors observed can be equated to accuracy, this is a noticeable difference over the percentage for the opinion measure on FIM accuracy. The opinion response showed only 13 percent of the technicians agreed that the FIM is accurate. The distributions by demographic factor for error reporting are provided in Appendix F. Since only one response was to be marked for this question, several interesting distributions are evident when examining this data. For the AFSCs, over 30 percent of the technicians with 452X2A, 452X2B, 452X2C, and 462X0 AFSCs told their supervisors an error in the FIM had been found. Two AFSCs, 45272 and 452X5, reported using the AFTO 22 system over 40 percent of the time. For skill level and FIM error reporting, one would expect that the higher the skill level, the lower the percentage of technicians reporting to their supervisor that an FIM error had been found. What the responses indicate are that 5 level technicians have the highest percentage of technicians telling their supervisors an FIM error had been found. Additionally, 23 percent of the 7/9 level technicians are telling <u>their</u> supervisors an error was found in the FIM. In evaluating the FIM error reporting and the use of the AFTO 22 reporting system, 42 percent of the 7 or 9 level technicians responded as using the AFTO 22 system to report FIM errors.

Figure 17 provides the responses as to what area of the FIM the technicians would like to see improved. Three areas appear to dominate the technicians' opinions as to how the FIM should be improved. For fault trees, this is a surprising response in light of the technicians previous response distribution showing the fault trees as one of the FIM's most useful areas. In evaluating the isolation technique response, it can not be determined from this response if technicians are referring to the accuracy or usefulness of the FIM's fault isolation technique or are identifying some other shortfall of the FIM. The training

```
Improving the FIM                                       Frequency Percent

Improve           |*****                                   27       7.24
  Illustrations   |
More Step-By-     |******                                  30       8.04
  Step Procedures |
Improve Fault     |*********************                  107      28.69
  Tree Accuracy   |
Improve Isolation |******************                      90      24.13
  Technique       |
Improve Indexes   |****                                    20       5.36
Improve Training  |************                            72      19.30
Other             |******                                  27       7.24
                   ---+---+---+---+---+---+
                     20  40  60  80  100 120

                            Responses
```

Figure 17. Survey Response for Improving the FIM

response is also difficult to evaluate. As noted in the previous discussion on the type training received, the responses were not mutually exclusive and technicians could have received any possible combination of the different types of training identified. As such, it can only be stated that the training technicians receive on the FIM appears to be a significant concern to the technicians. The demographic distributions for this question are provided in Appendix G. Fifty percent or more of the technicians with the AFSC 452X5 and 452X2A responded that the fault trees are the single FIM area requiring improvement. For skill levels, improving the training had the highest percentage response with fault tree improvement just .12 percent lower.

Figure 18 identifies the other fault isolation methods maintenance technicians use. Each of these methods is not mutually exclusive as all applicable entries for the question were to be marked. The single largest method is to

```
Other Fault Isolation Methods                        Frequency  Percent

Approved QA     |********                                 103     18.58
  Procedures    |
Experience      |**********************                   261     47.54
Contractor      |******                                    68     12.39
  Data          |
Cheat Sheets    |******                                    65     11.84
Other           |****                                      53      9.65
                 ----+----+----+----+----+
                    60  120  180  240  300

                          Responses
```

Figure 18. Survey Response for Other Methods of Fault Isolation

resort to experience. It can not be determined from these data if this experience was the individual's personal experience or whether technicians were dependent on the experience of other personnel. The second largest response was the use of locally approved QA procedures. It can not be determined if any of these QA approved procedures have been submitted through the AFTO 22 process. Further analysis was accomplished on the other methods data to determine the following:

1) Is there a base at which approved QA procedures appear more prevalent?

2) Is there any one AFSC for which experience appears to be the more significant other method used for fault isolation?

3) Is there any one basé or AFSC for which cheat sheets appear to be more prevalent?

Tables 8 and 9 provide the distribution comparisons. For each AFSC and base, the distribution percentages, as determined by Table 6, are provided in parentheses. These

Table 8. AFSC and Fault Isolation Technique Comparison

AFSC	Experience	Cheat Sheets
452X2A (4.27)	15 (5.7)	3 (4.6)
452X2B (6.67)	17 (6.5)	4 (6.1)
452X2C (4.80)	10 (3.8)	6 (9.2)
45272 (6.40)	22 (8.5)	3 (4.6)
452X4B (40.27)	93 (35.6)	23 (35.4)
452X5 (8.27)	23 (8.8)	2 (3.1)
462X0 (29.33)	81 (31.2)	24 (37.0)
Total	261	65

percentages are then compared to the distribution percentages for each area under consideration. The assumption is that each fault isolation method has approximately the same distribution as the sample's AFSC or base distribution, e.g., the samples will are homogeneous.

The results indicate that for the 261 technicians who reported depending upon experience as another method to perform fault isolation, the distributions appear to be approximately the same as the sample's AFSC distribution. The same seems to be true for the 65 technicians who reported using some form of cheat sheet to perform fault isolation. However, the AFSC 462X0 could be interpreted as using cheat sheets more than other AFSCs.

In evaluating the base and fault isolation technique, the results indicate that for QA procedures, MacDill AFB appears to have more QA approved procedures for use during fault isolation than their sample distribution would account for. In the use of cheat sheets, Luke AFB technicians

Table 9. Base and Fault Isolation Technique Comparison

Base		Approved QA Procedures	Cheat Sheets
Homestead	(16.8)	11 (10.6)	10 (15.4)
Shaw	(18.4)	13 (12.6)	10 (15.4)
MacDill	(20.3)	31 (30.1)	10 (15.4)
Luke	(18.7)	21 (20.3)	17 (26.2)
Moody	(13.1)	11 (10.6)	9 (13.8)
Hill	(12.8)	16 (15.5)	9 (13.8)
	Total	103	65

appear to use cheat sheets more than their sample distribution would account for.

Normality Test.

Appendix H includes the outputs from the PROC UNIVARIATE procedure in SAS. As can be noted, the histogram is approximately bell shaped, or normal, and the Wilk-Shapiro test has a test statistic of 0.98. Graphical representation of the test statistic can be seen from the normal probability plot. This plot represents a "reference straight line that is drawn using the sample mean and standard deviation. If the data is normal, they [data values: *] should tend to fall along the reference line" (SAS, 1188). This result allows the use of parametric statistical testing for Research Questions 2, 3, 4, and 5.

Pearson Correlation Coefficients

Research Question 1. This research question investigates whether or not a relationship exists between the maintenance technicians' perceptions of the usefulness and accuracy of various features of the FIM and their use of the FIM.

Research Hypothesis 1.1. This research hypothesis states that there is a positive correlation between the technician's perceptions of the usefulness of various elements of the FIM and their use of the FIM. The correlation values for these perceptions and FIM use are shown in Table 10. Several significant correlations are obtained. Using Kidder's values for interpreting

Table 10. Correlations for Technician's Perceptions of the Usefulness of the FIM and Their Use of the FIM

Usefulness Variable	FIM Use
Illustration Usefulness	.16707 ***
Procedure Usefulness	.09356 *
Fault Tree Usefulness	.15771 **
Troubleshooting Usefulness	-.00307
Index Usefulness	.22799 ****
FIM Usefulness for New Technicians Assigned to the F-16	.19810 ****
FIM Usefulness for Experienced Technicians Assigned to the F-16	.22474 ****
FIM Training Received	.17579 ***
FIM Usefulness for OJT	.25264 ****

* $p < .1$ ** $p < .01$ *** $p < .001$ **** $p < .0001$

correlations, the FIM elements of illustrations, fault trees, and indexes are supported but have a weak relationship with the use of the FIM. The FIM procedure's correlation was also supported but there is not much of a relationship. The usefulness of the FIM's troubleshooting logic was not correlated at all with use of the FIM. Additional correlations are calculated for the use of the FIM and 1) whether new technicians perceived the FIM to be useful, 2) whether experienced technicians perceived the FIM to be useful, 3) whether FIM training is perceived as adequate, and, 4) whether the FIM is perceived as useful for OJT. Here too, all of the correlations are weak but have significant p-values ($p < .001$).

Research Hypotheses 1.2. This research hypothesis states that there is a positive correlation between the technician's perceptions of the accuracy of various elements of the FIM and their use of the FIM. The correlation values for the maintenance technician's perceptions of the accuracy of the various elements of the FIM and their use of the FIM are shown in Table 11. Using Kidder's values for interpreting correlations, the research hypothesis is supported for the FIM elements of troubleshooting and index accuracy although the relationship is considered weak. The troubleshooting accuracy has the most significant p-value ($p < .0001$). The FIM element accuracy variables for illustrations, fault trees, and procedures are not correlated at all with FIM use.

Table 11. Correlations Between Technician's Perceptions of the Accuracy of the FIM and Their Use of the FIM

Accuracy Variable	FIM Use
Illustration Accuracy	.08440
Procedure Accuracy	.02509
Fault Tree Accuracy	.02289
Troubleshooting Accuracy	.22196 ****
Index Accuracy	.16771 **

* p < .1   ** p < .01   *** p < .001   **** p < .0001

Discussion. A comparison of the FIM factors that are correlated with FIM use and the response percentages for each opinion question for these FIM factors is presented in Table 12. From this table, it is seen that for all non-correlated FIM accuracy variables, the cumulative opinion question responses indicate that maintenance technicians have significant dissatisfaction with the accuracy of these FIM elements. It can also be noted that this condition does not hold for the troubleshooting usefulness element. As was noted in the previous section discussing the FIM opinion responses, the two troubleshooting usefulness questions are significantly different. Further examination of the questions indicate that they are posing two separate ideas relating to the usefulness of troubleshooting. Question 31 addresses FIM troubleshooting usefulness for faults not identified in the FIM. Question 34 evaluates whether the FIM troubleshooting

Table 12. FIM Variable and Opinion Question Comparison

FIM Variable	Opinion Question Response Agree %	Disagree %
Useful to new technicians	68 *	8.53
Useful to experienced technicians	63 *	7.67
Training received was adequate	52.8 *	17.33
FIM Usefulness for OJT	66 *	8
Illustration Usefulness	30.66*	23
Procedure Usefulness	57 *	10
	18.9 *	37
Fault Tree Usefulness	48.8 *	10.53
Troubleshooting Usefulness	37	22
	16	37
Index Usefulness	54.67*	5.86
Troubleshooting Accuracy	38 *	19
Illustration Accuracy	16	35.2
Procedure Accuracy	14.27	42.13
Fault Tree Accuracy	11.33	44
Index Accuracy	44 *	10

* Indicates some correlation

logic takes too much time. Correlating each of these questions separately with FIM use shows each of these questions to be weakly correlated. Specifically, the correlation for question 31 was 0.11044 (p-value .0325) and question 34 was -0.12416 (p-value .0161). As was noted in Chapter III, the FIM elements for correlation with FIM use were a combination of the results for the questions relating to a particular FIM element. In this case, the negative correlation of question 34 adversely interacts with the positive correlation of question 31 and results in the cumulative response for troubleshooting usefulness to be non-correlated. This also explains why the Cronbach's Coefficient Alpha presented at the beginning of this chapter was so poor.

ANOVA

Research Question 2. This research question evaluates whether differences by demographic factor exist as to the maintenance technician's use of the FIM. The ANOVA and Scheffe means test results for Research Hypotheses 2.1 are provided in Appendix I.

Research Hypothesis 2.1. This hypothesis states that there is no difference by the various demographic factors as to the maintenance technician's use of the FIM. Review of the Scheffe means test results in Appendix I indicates that none of the classes in the demographic factors of skill level, AFSC, grade, base of assignment, education level, maintenance experience, F-16 experience, and FIM experience, have any significant difference in means for the use of the FIM. This supports the null hypothesis that demographic factors make no difference in the extent of FIM use by maintenance technicians.

Research Question 3. This research question evaluates whether any differences exist by demographic factor on the maintenance technician's perceptions of FIM usefulness or accuracy FIM. The ANOVA and Scheffe means test results for Research Hypotheses 3.1 and 3.2 are provided in Appendices J and K.

Research Hypothesis 3.1. This hypothesis states that there is no difference by the various demographic factors as to the maintenance technician's perceptions of FIM usefulness. The demographic factors of skill level, grade, base of assignment, education, maintenance experience, F-16 experience and FIM experience all show no significant difference in means for the combined usefulness variable. These results support the null hypothesis that there is no difference by demographic factor in the maintenance technicians' perceptions of the usefulness of the FIM. For AFSCs, the results indicate that the AFSC 45272 had a significantly lower use of the FIM than the AFSCs 452X5 and 462X0. Therefore, for AFSCs, we reject the null hypothesis and accept the alternate that the demographic factor AFSC class 45272 has significantly different perceptions of FIM usefulness compared to other AFSCs.

Research Hypothesis 3.2. This hypothesis states that there is no difference by the various demographic factors as to the maintenance technician's perceptions of the accuracy of the FIM. The demographic factor grade and base of assignment show no significant difference in means for the combined accuracy variable. This supports the null hypothesis that demographic factors make no difference in the maintenance technician's perceptions of FIM accuracy. The remaining demographic variables all support rejection of the null hypothesis and acceptance of the alternate, i.e., demographic factors make a difference in the extent to which maintenance technicians perceive FIM accuracy. The ANOVAs associated with each test all have a p-value of .0001. The differences between classes for each demographic factor will be discussed separately.

Skill Level. The 7/9 skill level technicians have a significantly lower mean than the 3 and 5 skill level technicians for their perceptions of FIM accuracy. This means that 7/9 level technicians perceive the accuracy of the FIM to be significantly less than the perceptions of FIM accuracy by 3 and 5 level technicians. There is no significant difference in means between 3 and 5 level technicians.

AFSC. The AFSC 45272 has a significantly lower mean than the AFSCs 462X0, 452X4B, 452X2C, and 452X5 for their perceptions of FIM accuracy. This indicates that technicians in the AFSC 45272 perceive the accuracy of the FIM to be significantly lower than technicians with an AFSC of 462X0, 452X4B, 452X2C, AND 452X5. There is no significant difference between means for any other AFSC comparison.

Education Level. Technicians with an Associates degree or higher education level have a significantly lower mean than technicians with a high school only education level. This indicates that technicians with an Associates Degree or higher level of education perceive the FIM's accuracy to be lower than technicians with a high school education level. There is no significant difference in means for any other education level comparison.

Maintenance Experience. Maintenance technicians with 7 to 12 years maintenance experience have a significantly lower mean than technicians with less than 7 years experience for their perceptions of FIM accuracy. This indicates that technicians with less than 7 years maintenance experience perceive the FIM to be more accurate than technicians with 7 to 12 years maintenance experience. There is no significant difference in means for any other maintenance experience level.

F-16 Experience. Maintenance technicians with 7 or more years F-16 experience have a significantly lower mean than technicians with less than 7 years experience for their perceptions of FIM accuracy. This indicates that technicians with more than 7 years F-16 experience perceive the FIM to be less accurate than technicians with less than 7 years F-16 experience. There is no significant difference in means for any other F-16 experience level.

FIM Experience. Maintenance technicians with less than 2 years FIM experience have a significantly higher mean than technicians with 2 years or more FIM experience for their perceptions of FIM accuracy. This indicates that technicians with more than 2 years FIM experience perceive the FIM to be less accurate than technicians with less than 2 years FIM experience. There is no significant difference in means for any other FIM experience level.

Research Question 4. This research question evaluates whether any differences exist by FIM level of use on the maintenance technician's perceptions of FIM usefulness or accuracy. The ANOVA and Scheffe means tests results for Research Hypotheses 4.1 and 4.2 are provided in Appendices L and M.

Research Hypothesis 4.1. This hypothesis states that the maintenance technicians' perceptions of FIM usefulness do not influence their use of the FIM. The results for technicians who use the manual 51 - 75 percent of the time supports the null hypothesis that the technician's perceptions of FIM usefulness does not influence their use of the FIM. Results for the technicians who use the FIM 76 - 100 percent of the time support the alternate hypothesis. These technicians have a significantly higher mean for perceiving the FIM to be more useful than those technicians who use the manual 50 percent or less of the time. This indicates that technicians who use the manual more, i.e., 76 - 100 percent, perceive the FIM to be more useful than the technicians who use the manual less, i.e., 50 percent or less.

Research Hypothesis 4.2. This hypothesis states that the maintenance technician's perceptions of FIM accuracy does not influence their use of the FIM. Results for the technicians who use the manual over 0 - 25 percent of the time supports the null hypothesis that the technician's perceptions of FIM accuracy does not influence their use of the FIM. The results for technicians who use the FIM over 51 percent of the time support the alternate hypothesis because they have a significantly higher mean for perceiving the manual to be more accurate than those technicians who use the manual 26 - 50 percent of the time. This indicates that the technicians who use the FIM more, i.e., 51 percent or more, perceive the manual to be more accurate than technicians who use the manual less, i.e., 26

- 50 percent of the time. There is no significant difference in means for technicians who use the manual 0 - 25 percent of the time.

Research Question 5. This research question evaluates whether differences by demographic factor exist as to the maintenance technician's satisfaction with the FIM. The ANOVA and Scheffe means test results for Research Hypothesis 5.1 are provided in Appendix N.

Research Hypothesis 5.1. This hypothesis states that there is no difference by the various demographic factors as to the maintenance technician's satisfaction with the FIM. The demographic factors of grade and base of assignment show no significant difference in means for the satisfaction variable and therefore supports the null hypothesis that demographic factors make no difference in the maintenance technician's satisfaction with the FIM. The remaining demographic variables all support rejection of the null hypothesis and acceptance of the alternate, i.e., demographic factors do make a difference in satisfaction maintenance technicians have with the FIM. The ANOVAs associated with each test all have a p-value of .0001. The differences between classes for each demographic factor is discussed separately.

Skill Level. The 7/9 skill level technicians have a significantly lower mean than the 3 skill level technicians for their satisfaction with the FIM. This indicates that the 7/9 level technicians' satisfaction with the FIM is significantly less than the 3 level technicians' satisfaction with the FIM. Technicians in the 5 skill level show no significant difference in means for their satisfaction with the FIM over any of the other skill levels.

AFSC. The AFSC 45272 technicians have a significantly lower mean than those with AFSCs 462X0, 452X4B, and 452X2C for their satisfaction with the FIM. This indicates that technicians in the AFSC 45272 have a significantly lower satisfaction value than technicians in the 462X0, 452X4B, and 452X2C AFSCs. Technicians with AFSCs of 452X2B, 452X5, and 452X2A show no significant difference in means for their satisfaction with the FIM over any other AFSC.

Education Level. Technicians with an education level higher than a high school education level, i.e., high school + or Associate Degree, have a significantly lower mean than technicians with a high school only education level for their satisfaction level with the FIM. This indicates that technicians with a higher education level have a significantly lower satisfaction level with the FIM than technicians with a high school education level. There is no significant difference in the means between technicians with a high school + education level and technicians with an Associate Degree or higher education level.

Maintenance Experience. Maintenance technicians with 12 years or more maintenance experience have a significantly lower mean than technicians with less than 2 years maintenance experience for their satisfaction with the FIM. This indicates that technicians with less than 2 years maintenance experience are more satisfied with the FIM than technicians with 12 years or more maintenance experience. Technicians with 2 to 12 years maintenance experience show no significant difference in means for their satisfaction of the FIM over any other year group.

F-16 Experience. Maintenance technicians mean than technicians with less than 2 years F-16 experience for their satisfaction with the FIM. Technicians with 7 years or more F-16 experience have a significantly lower mean than technicians with 2 - 7 years F-16 experience. This indicates that technicians with more F-16 experience are less satisfied with the FIM than technicians with less F-16 experience.

FIM Experience. Maintenance technicians with 2 - 7 years FIM experience have a significantly lower mean than technicians with less than 2 years FIM experience for their satisfaction with the FIM. Technicians with 7 years or more FIM experience have a significantly lower mean than technicians with 2 - 7 years FIM experience. This indicates that technicians with more FIM experience are less satisfied with the FIM than technicians with less FIM experience.

Open Ended Question. Table 13 provides a summary of the open ended question. Any comments that are reflected through one of the specific FI questions in Section III of the survey, are not included in this table, e.g., a discussion on improving illustrations and that was the area the respondent had marked for the question for improving the FIM. Also, all of these comments are not mutually exclusive and several respondents provided more than one comment or suggestion.

Summary

This chapter outlines analysis results of 375 F-16 Fault Isolation Manual survey responses. These analyses included Cronbach's Coefficient Alpha, frequency responses for each survey question, Pearson Correlation Coefficients, and ANOVA and Scheffe means test results. The conclusions from these analyses are presented in Chapter V.

Table 13. Open Ended Question Comments

Comment	Number of Responses
FIMs cause the replacement of components that are not bad.	1
FIMs need more voltage checks/resistance tables inaccurate/doesn't address cold solders on pins.	4
FIMs don't include all the faults or solutions; the general fault codes are unhelpful	14
Several fault codes lead to the same corrective action	1
Improve the schematics	1
Main problem with the FI is personnel aren't submitting AFTO 22s or Form 1000s. Evaluations of these are inadequate because of a lack of knowledge by the evaluator in the area being evaluated.	3
FIMs are inadequate for new equipment.	2
FIM is written with the assumption that the fault is present during troubleshooting	2
FIMs need to be provided for a particular block of aircraft.	2
Constant changes, TCTOs and upgrades, make the FI almost useless.	6
FIMs don't adequately address wiring problems/solutions.	2
Too much duplication of schematics	1
Start an F-16 Newsletter identifying new and unusual write-ups/ corrective actions so aren't waiting on TO updates	1
Identify other possibilities when Fault Trees are exhausted	2
Until Rivet Workforce, I never used an FIM.	1
The F-16A-70FI-00-1 should have all the tables and schematics put with supplemental data.	1
Difficult to find a good fault code.	1
FIs are too big and I spend a lot of time searching for information.	2

V. Conclusions and Recommendations

Introduction

This chapter first summarizes the analysis results of the research on the F-16 Fault Isolation Manuals in the context of the research questions presented in Chapter I. The conclusions drawn from these findings are then presented followed by lessons learned from the research and recommendations resulting from the conclusions. Finally, recommendations for further research are presented.

Research Question 1

This objective was to determine if the technician's use of the FIM is related to the technician's perceptions of FIM usefulness or accuracy. Table 14 summarizes the correlational analysis addressed in Chapter IV. The

Table 14. Summary of Results for Research Question 1

FIM Variable	Correlated
Useful to new technicians	Yes
Useful to experienced technicians	Yes
Training received was adequate	Yes
FIM Usefulness for OJT	Yes
Illustration Usefulness	Yes
Procedure Usefulness	Yes
Fault Tree Usefulness	Yes
Troubleshooting Usefulness	No
Index Usefulness	Yes
Troubleshooting Accuracy	Yes
Illustration Accuracy	No
Procedure Accuracy	No
Fault Tree Accuracy	No
Index Accuracy	Yes

correlational analysis demonstrates that there is a relationship between the use of the FIM and the maintenance technician's perceptions of the usefulness and accuracy of various elements of the FIM. Some additional correlations relating to training and use of the FIM by new and experienced technicians were accomplished and are also found to be correlated to the technician's use of the FIM.

Although none of the correlations could be considered strong according to Kidder, the comparison of the non-correlated variables with the opinion response questions provide an interesting insight; all FIM accuracy elements that were non-correlated with FIM use had significant disagreement by maintenance technician's as to the accuracy of that particular FIM element.

Research Question 2

This objective was to determine whether differences exist by demographic factor as to the maintenance technician's use of the FIM. Statistical testing using ANOVA analysis shows no significant differences for FIM use between different classes within the demographic factors of skill level, grade, AFSC, education level, base of assignment, aircraft maintenance experience, F-16 experience, or FIM experience.

Research Question 3

This objective was to determine whether differences exist by demographic factor as to the maintenance technician's perceptions of FIM usefulness or accuracy. Statistical testing shows significant differences between the different classes within the various demographic factors for perceptions of the usefulness or accuracy of FIMs. Table 15 summarizes the ANOVA analysis completed in Chapter IV.

Table 15. Summary of Results for Research Question 3

Demographic Factor	Differences in Technician Perception: Usefulness	Accurate
Skill Level	No	Yes
AFSC	Yes	Yes
Grade	No	No
Base of Assignment	No	No
Education	No	Yes
Maintenance Experience	No	Yes
F-16 Experience	No	Yes
FIM Experience	No	Yes

Two demographic factors, grade and base, showed no differences as to whether maintenance technicians perceive the FIM to be more useful or accurate. The remaining demographic factors all indicate that technician's within those factors have different perceptions as to FIM usefulness or accuracy. Furthermore, the accuracy of the FIM appears to be significantly more important to technicians than the usefulness of the FIM.

Research Question 4

The objective of this research question was to determine whether differences exist between different FIM use levels as to the technician's perceptions of FIM usefulness or accuracy. Table 16 summarizes the results of the ANOVA analysis in Chapter IV. The results indicate that technicians who use the FIM over 76 percent of the time for troubleshooting, perceive the FIM to be more useful than technicians who use the FIM 50 percent or less of the time. In the area of FIM accuracy, technicians who use the FIM over 50 percent of the time for troubleshooting, perceive the FIM to be more accurate than technicians who use the FIM between 26 and 50 percent of the time.

Table 16. Summary of Results for Research Question 4

FIM Use	Comparison of Technician's Perceptions	
Level %	Usefulness	Accuracy
0 - 25	< 76 - 100	No Differences
26 - 50	< 76 - 100	< 50 - 100
51 - 75	No Differences	> 26 - 50
76 - 100	> 0 - 50	> 26 - 50

<: Less than >: More than

Research Question 5

The objective of this research question was to determine whether differences exist by demographic factor as to the maintenance technician's satisfaction with the FIM. Table 17 summarizes the ANOVA analysis results in Chapter IV. As can be noted from the table, technicians within the various demographic factors who have more experience, have less satisfaction with the FIM than technicians with less experience. This cannot be strictly interpreted as being true for the demographic factor of AFSC. The AFSC with the lower satisfaction level, 45272, are the 7-level avionics maintenance technicians, i.e., the 7-level technicians from the AFSCs 452X2A, 452X2B, and 452X2C. All other AFSCs in the sample are a combination of technicians with 3, 5, 7, or 9 skill levels.

Table 17. Summary of Results for Research Question 5

Demographic Factor	Differences in Technician Perception Satisfaction	
Skill Level	7/9 level	< 3 level
AFSC	45272	< 162X0, 452X4B and 452X2C
Grade	No Differences	
Base of Assignment	No Differences	
Education	High School	> all others
Maintenance Experience	12 years +	< 2 years or less
F-16 Experience	7 years +	< 2 - 7 years < 2 years or less
Fault Isolation Manual Experience	7 years +	< 2 - 7 years < 2 years or less

<: Less than >: More than

Research Conclusions

Several conclusions can be drawn from this research. However, it is important to again point out that any causal inference from the findings of this research cannot be done.

The first conclusion is general in nature. As had been noted throughout the literature review, maintenance technicians have expressed dissatisfaction with TOs for many years. From this research, it appears that FIMs are no better than their precursors. An example of this a comparison of this research with the results of the 1975 Johnson study. In that study, 54.8 percent of the technicians surveyed felt that the LTTAs, the precursor of the current FIM system, always or usually led to correct solution of the problem. For this study, only 11.94 percent of the technicians surveyed felt that the FIM fault tree is always accurate in correcting faults (as measured by survey question 30).

The second and third conclusions are related to the fact that the relationship between demographic factors, perceptions of FIM usefulness and accuracy, and use of the FIM are interdependent. For the second conclusion, although no differences exist among demographic factors as to the use of the FIM by maintenance technicians, differences by demographic factor as to the technician's perceptions of FIM usefulness and accuracy do exist. It is this researcher's opinion that the technicians' perceptions of FIM usefulness and accuracy in turn influence their use of the FIM. If technicians have bad experiences in their use of the FIM, either through the FIM's usefulness or accuracy, then technicians will not use the FIM.

The third conclusion is that technicians who use the FIM more perceive the FIM to be more useful and accurate than technicians who use the FIM less. As was noted in the

1985 Gemas study on the F-16. From this study, there is evidence supporting the inherent accuracy of the FIM. In the study, the error rate of the F-16 FIM logic trees was approximately 10 percent. Even assuming a doubled error rate for the logic trees, technicians would still have accurate information for four out of five faults. Taking the conclusion of this research and the Gemas study together, it can be implied that the technician's who use the FIM more have a more realistic perception of FIM accuracy.

The fourth conclusion is that the perception of FIM accuracy is the most influential perception to technicians. As can be noted from Tables 15 and 16, nine of the twelve differences of technicians' perceptions of accuracy were significant. For FIM usefulness, only four of twelve differences in technicians' perceptions were significant.

The fifth conclusion is that technicians with more experience and education are less satisfied with the FIM. These technicians also perceive the FIM to be less useful and accurate than technicians with less experience or education. The reasons for this are two-fold. First, higher skill level technicians are troubleshooting the malfunctions that do not have a specific fault code or are not specifically addressed in the FIM. As such, these technicians' perceptions of FIM usefulness or accuracy would be less than lower skill level technicians. This problem of inadequate identification of faults within troubleshooting manuals is not new and has been a finding in several technical manual studies (Holbert, 1975; Johnson, 1975; Hughes, 1983; Chenzoff, 1984). The effects of a higher education is the second reason for this conclusion. Technicians who improve themselves through higher education are exposed to new ideas and new technologies. They are more aware of what computer systems are capable of and what can be done with and to computer systems. Therefore, they have higher expectations of how the F-16 fault isolation system and its related FIM should operate.

Finally, the use of the FIM appears to be consistent throughout the sample. There is no evidence of any unique policies or procedures at any base that influence the use or non-use of the FIM.

Lessons Learned

The following are lessons learned by the researcher which could be applied to any similar research effort or a duplication of this research.

1. Questions should be mutually exclusive if possible. Two questions on the survey instrument in this research, 9 and 50, were not mutually exclusive and allowed the marking of all applicable entries. Analysis of the data gained through this method was limited and had to be manually

manipulated before any statistical analysis could be accomplished. If necessary, the use of multiple questions relating to the subject under investigation should be used.

2. The use of a six-point Likert scale is highly recommended. As was noted in this research, on average, over 40 percent of the population used the neutral position of the Likert scale. This tended to skew the questions mean to the middle and could hide the sample's true response.

3. The survey questions for each element to be measured should be reviewed. Questions measuring a particular attribute of an element need to be similar. If they are not, a situation as discussed in the Cronbach Alpha sub-section of Chapter IV could result. More than one pre-test of the survey instrument would be beneficial in precluding this situation.

4. The use of absolutes in the survey questions should be thoroughly evaluated. The use of absolutes such as always or never, could drive responses to the middle of the response scale.

Recommendations

1. The use of the FIM by base level maintenance technicians should be enforced. Almost 60 percent of the technicians in the sample reported using the FIM less than 50 percent of the time, yet, technicians who report using the FIM more perceive the FIM to be more useful and accurate.

2. The F-16 System Program Office and the Ogden Air Logistics Center should take actions to improve the accuracy of the FIMs. As was found by Gemas, the F-16 FIM technical order acquisition program specifications "permit the entire verification and validation of FR/FI manuals by desk top analysis" (Gemas, 1985:13). The verification portion is where a TO's data is evaluated as being useful and accurate by USAF maintenance technicians. Conversation with the F-16 System Program Office technical order office indicate this policy is still in effect. The results of this research indicate that this policy continues to adversely affect the technicians' use of the FIM.

Recommendations for Further Research

The following recommendations are made for additional research into the use of the FIMs and electronic maintenance aid programs.

1. As was previously noted, causation for the use or non-use of the FIM due to the perceptions of accuracy or usefulness could not be established from this research. An experimental design should be developed to evaluate whether the usefulness or accuracy of the FIMs directly contribute to the maintenance technician's use of the FIM. It is through experimental design that the most powerful support for causation is provided (Emory, 60). Since FIM updates are regularly accomplished through the F-16 SPO, an experimentation program would not be difficult to establish.

2. Conduct additional studies for other weapon system FIMs to determine their usefulness or accuracy. Statistically compare these results with the results of this research to determine any differences. Differences between FIM studies could be indicative of a program that provides more useful or accurate FIMs.

3. Conduct a study to determine if any relationship exists as to the maintenance technician's perceptions of FIM usefulness and accuracy to a F-16 wing's Cannot Duplicate and Re-Test OK (RTOK) rates.

4. There is a significant amount of research going into the development of an electronic maintenance aid for fault isolation and the use of artificial intelligence in accomplishing fault isolation. These programs need to have specific guidelines implemented to ensure the systems are user friendly and provides accurate information to the maintenance technician. If such guidelines are not established early in the program, the systems will suffer from the same problems as the current paper based system.

Appendix A: F-16 Fault Isolation Manual Questionnaire

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY
AIR FORCE INSTITUTE OF TECHNOLOGY
WRIGHT-PATTERSON AIR FORCE BASE OH 45433-6583

8 MAY 19??

REPLY TO ATTN OF: LSM

SUBJECT: Fault Isolation Manual Acceptance and Usability Survey

TO:		
31TFW/MA	58TT8/MA	363TFW/MA
56TTW/MA	347TFW/MA	388TFW/MA

1. One of the most important jobs in the Air Force is the maintenance of aircraft. The purpose of this questionnaire is to measure maintenance technicians' attitudes toward Fault Isolation Manuals and assess specific elements of the manual to determine where improvement is needed. We are asking your help in this essential activity.

2. Recent field evaluations indicate that Fault Isolation Manuals may be deficient. Unfortunately, the specific problems of the manuals were not addressed during these field evaluations. You can provide valuable guidance by answering the attached questionnaire. Your answers will help in the improvement of the Fault Isolation Manuals.

3. Because your honest opinion is critical to this survey, responses will be treated confidentially. No individual will be identified in the reporting of results of this survey.

4. Please return your responses to your wing point of contact. If you are interested in the results of this survey, please note this, with your name and organization, in question 51. Thank you for your help.

FREDERICK W. WESTFALL, Lt Col, USAF
Head, Dept of Log Mgt
School of Systems and Logistics

Atch
Questionnaire

THIS PAGE OF THE F-16 FAULT ISOLATION MANUAL
QUESTIONNAIRE INTENTIONALLY LEFT BLANK.

F-16 FAULT ISOLATION MANUAL QUESTIONNAIRE

This survey consists of three sections. Section one is a short series of demographic job environment questions. Sections two and three contain opinion and attitude questions about your use of fault isolation manuals. Mark your answer to each question on both this questionnaire and the enclosed electronic data scan sheet. Darken the spaces on the electronic data scan answer sheet with a number 2 pencil. For question 51, write on the questionnaire only. After completing the survey and the data scan sheet, please return both items back to the wing point of contact.
********************************THANK YOU**********************************

Section I. Record your response by circling the number of the answer and entering that selection on the electronic data scan sheet.

1. What is your current grade?

1. E-1	4. E-4	7. E-7
2. E-2	5. E-5	8. E-8
3. E-3	6. E-6	9. E-9

2. What is your AFSC?

1. 452X4B	4. 452X5	7. 45272
2. 452X2B	5. 452X2C	8. Other __________
3. 462X0	6. 452X2A	

3. What is your skill level?

1. 3 level	3. 7 level
2. 5 level	4. 9 level

4. At what base are you stationed?

1. Homestead	3. MacDill	5. Moody	7. Other __________
2. Shaw	4. Luke	6. Hill	

5. Your highest level of education completed to date is:

1. Non-high school graduate
2. High school graduate or GED
3. High school graduate with some college credit
4. Associate degree
5. Associate degree with some additional credit
6. Bachelors degree
7. Other ______________________________

6. What are your total years in aircraft maintenance?

   1. less than 1 year
   2. 1 year or more, but less than 2 years
   3. 2 years or more, but less than 7 years
   4. 7 years or more, but less than 12 years
   5. 12 years or more

7. How long have you been working on F-16 aircraft?

   1. less than 1 year
   2. 1 year or more, but less than 2 years
   3. 2 years or more, but less than 7 years
   4. 7 years or more, but less than 12 years
   5. 12 years or more

8. How long have you used F-16 Fault Isolation Manuals?

   1. less than 1 year
   2. 1 year or more, but less than 2 years
   3. 2 years or more, but less than 7 years
   4. 7 years or more, but less than 12 years
   5. 12 years or more

9. The training you received on the use of F-16 Fault Isolation Manuals has been through (mark all applicable entries):

   1. Air Training Command (ATC) Technical Training School
   2. Field Training Detachment (FTD) Technical Training
   3. On-the-Job Training
   4. Contractor Training School
   5. Maintenance Training (MAT)
   6. Aircraft Maintenance Qualification Program (AMQP)
   7. Other ______________________________________

Section II. These questions relate to your attitudes, beliefs, and experience using fault isolation manuals. Read each question carefully and then decide on your level of agreement or disagreement. Using the scale below to best represent your response, mark the questionnaire by circling the appropriate number and enter that selection on the electronic data scan sheet.

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
[1]	[2]	[3]	[4]	[5]

[1]-----------[2]-----------[3]----------[4]----------[5]

****

10.	The fault isolation manuals I use are completely satisfactory.	1	2	3	4	5
11.	The fault isolation manuals I use are always accurate.	1	2	3	4	5
12.	Fault isolation manuals are useful to new technicians assigned to the F-16.	1	2	3	4	5
13.	Fault isolation manuals are useful to experienced technicians assigned to the F-16.	1	2	3	4	5
14.	The training I have received for using the fault isolation manual has been adequate.	1	2	3	4	5
15.	For on-the-job training, fault isolation manuals are valuable in helping someone learn the aircraft.	1	2	3	4	5
16.	Fault isolation manuals always correctly isolate maintenance problems.	1	2	3	4	5
17.	The <u>illustrations</u> in fault isolation manuals I use are completely satisfactory.	1	2	3	4	5
18.	Fault isolation manuals should have more <u>illustrations</u>.	1	2	3	4	5
19.	Fault isolation manual <u>illustrations</u> are too small to see details.	1	2	3	4	5
20.	<u>Illustrations</u> of components referenced in fault isolation manuals are always accurate.	1	2	3	4	5
21.	Fault isolation manual <u>illustrations</u> are convenient and easy to use.	1	2	3	4	5

STRONGLY DISAGREE [1]	DISAGREE [2]	NEUTRAL [3]	AGREE [4]	STRONGLY AGREE [5]

****

22.	Fault isolation manual fault tree illustrations are always accurate.	1	2	3	4	5
23.	Fault isolation manual procedures for fault correction are always accurate.	1	2	3	4	5
24.	Fault isolation manual procedures for fault isolation are always accurate.	1	2	3	4	5
25.	Procedures in fault isolation manuals are easy to understand.	1	2	3	4	5
26.	Fault isolation manual procedures provide all necessary information to isolate faults.	1	2	3	4	5
27.	Fault isolation manual fault trees are useful in performing fault isolation.	1	2	3	4	5
28.	Fault isolation manual fault trees are always easy to understand.	1	2	3	4	5
29.	Fault isolation manual fault trees are always accurate in isolating faults.	1	2	3	4	5
30.	Fault isolation manual fault trees are always accurate in correcting faults.	1	2	3	4	5
31.	Fault isolation manuals are useful for troubleshooting even if the specific fault is not identified in the manual.	1	2	3	4	5
32.	For my particular job, fault isolation manuals are an accurate source of troubleshooting information.	1	2	3	4	5
33.	Fault isolation manuals provide accurate troubleshooting instructions for fault isolation.	1	2	3	4	5
34.	It takes too much time to troubleshoot a problem using fault isolation manuals.	1	2	3	4	5

STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
[1]	[2]	[3]	[4]	[5]

[1]------------[2]-------------[3]-----------[4]----------[5]
****

35.	Fault isolation manual indexes are useful.	1	2	3	4	5
36.	Fault isolation manual indexes enable me to accurately locate the correct fault tree for a particular maintenance problem.	1	2	3	4	5
37.	I always receive the fault code for a maintenance problem, allowing me to enter fault isolation manuals to troubleshoot effectively.	1	2	3	4	5
38.	The fault codes I receive for a maintenance problem always correctly identify the subsystem with the fault.	1	2	3	4	5
39.	The fault codes I receive for a maintenance problem always correctly identify the fault.	1	2	3	4	5
40.	The fault isolation manual troubleshooting instructions are inaccurate for isolating faults.	1	2	3	4	5
41.	Fault isolation manual fault trees are inaccurate for use in isolating faults.	1	2	3	4	5
42.	Fault isolation manuals incorrectly isolate maintenance problems.	1	2	3	4	5
43.	The fault isolation manuals I use are unsatisfactory.	1	2	3	4	5
44.	Procedures in fault isolation manuals are difficult to understand.	1	2	3	4	5

SECTION III. Read each question carefully and decide on the response which best fits. Record your response by circling the number of the statement and entering that selection on the electronic data scan sheet.

45. For isolating faults, I use fault isolation manuals:

    1. 0% to 25% of the time
    2. 26% to 50% of the time
    3. 51% to 75% of the time
    4. 76% to 100% of the time

46. The most useful feature of fault isolation manuals is (answer only one):

    1. Fault Trees
    2. Simplicity
    3. Step-by-step procedures
    4. Illustrations
    5. Indexes
    6. Other ______________________________

47. The least useful feature of fault isolation manuals is (answer only one):

    1. Fault Trees
    2. Simplicity
    3. Step-by-step procedures
    4. Illustrations
    5. Indexes
    6. Other ______________________________

48. When I find an error (incorrect fault code, errors in fault trees, etc.) in the fault isolation manual, I (answer only one):

    1. Tell my supervisor
    2. Complete and submit an AFTO Form 22
    3. Ignore it
    4. Have never seen an error in the fault isolation manual
    5. Other ______________________________

49. What would most improve your use of the fault isolation manual? (answer only one)

    1. Improved illustrations
    2. More step-by-step written procedures
    3. Improved accuracy of the fault trees
    4. A more effective procedure or scheme to be followed in isolating malfunctions
    5. Improved indexes
    6. Improved training on the use of the fault isolation manual
    7. Other______________________________

50. When I don't follow the fault isolation manual steps, I use (mark all applicable entries):

    1. Locally developed procedures approved by Quality Assurance
    2. Personal experience
    3. Contractor provided data
    4. "Cheat sheets" (handwritten guides replicating the highlights of the Fault Isolation Manuals)
    5. Other ______________________________

51. If there is any other information you feel is not adequately addressed in this survey about your use of fault isolation manuals or the fault isolation manual itself, please provide it in the following space.

****

Please return the answer sheets and the survey booklet to the wing point of contact. Thank you for your participation and cooperation.

****

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Appendix B: F-16 Survey Question Frequencies

Question 1

```
Grade                                              Cum.              Cum.
                                            Freq   Freq   Percent   Percent
       |
E2     |******                                29     29      7.73      7.73
       |
E3     |***********                           54     83     14.40     22.13
       |
E4     |*********************                107    190     28.53     50.67
       |
E5     |************************             119    309     31.73     82.40
       |
E6     |**********                            49    358     13.07     95.47
       |
E7     |***                                   16    374      4.27     99.73
       |
E8     |                                       1    375      0.27    100.00
       ----+---+---+---+---+---+
          20  40  60  80 100 120

               Frequency
```

Question 2

```
AFSC                                              Cum.              Cum.
                                           Freq   Freq   Percent   Percent
         |
452X4B   |*********************             151    151     40.27     40.27
         |
452X2B   |***                                25    176      6.67     46.93
         |
462X0    |**************                    110    286     29.33     76.27
         |
452X5    |****                               31    317      8.27     84.53
         |
452X2C   |*                                  18    335      4.80     89.33
         |
452X2A   |*                                  16    351      4.27     93.60
         |
45272    |***                                24    375      6.40    100.00
         ----+---+---+---+---+-
            30  60  90 120 150

               Frequency
```

Question 3

```
Skill Level
                                           Cum.            Cum.
                                    Freq   Freq  Percent  Percent
           |
     3     |*****                     49     49    13.07    13.07
           |
     5     |********************* ·158    207    42.13    55.20
           |
     7     |**********************  162    369    43.20    98.40
           |
     9     |*                          6    375     1.60   100.00
          ----+---+---+---+---+---+
              30  60  90 120 150 180

                    Frequency
```

Question 4

```
Base
                                              Cum.            Cum.
                                       Freq   Freq  Percent  Percent
               |
Homestead      |******************       63     63    16.80    16.80
               |
Shaw           |*******************      69    132    18.40    35.20
               |
MacDill        |*********************    76    208    20.27    55.47
               |
Luke           |*******************      70    278    18.67    74.13
               |
Moody          |*************            49    327    13.07    87.20
               |
Hill           |*************            48    375    12.80   100.00
              ----+---+---+---+---+--
                  15  30  45  60  75

                     Frequency
```

Question 5

```
Education                                   Cum.             Cum.
                                      Freq  Freq  Percent  Percent
            |
Non high    |*                           1     1     0.27     0.27
   School   |
High school |*****                      81    82    21.60    21.87
   or GED   |
High school |******************        260   342    69.33    91.20
     +      |
Associates  |*                          13   355     3.47    94.67
            |
Associates  |*                          16   371     4.27    98.93
     +      |
Bachelors   |*                           4   375     1.07   100.00
   Degree   |
            -----+----+----+----+
                75  150  225  300

                   Frequency
```

Question 6

```
Maintenance Experience                      Cum.             Cum.
                                      Freq  Freq  Percent  Percent
            |
< 1 year    |*****                      39    39    10.40    10.40
            |
1 year <    |****                       27    66     7.20    17.60
  2 years   |
2 years <   |********************* 130   196    34.67    52.27
  7 years   |
7 years <   |******************        114   310    30.40    82.67
 12 years   |
+ 12 years  |**********                 65   375    17.33   100.00
            ----+---+---+---+---+---+
               25  50  75 100 125 150

                   Frequency
```

Question 7

F16 Experience

```
                                              Cum.            Cum.
                                        Freq  Freq  Percent  Percent
             |
< 1 year     |******                      58    58    15.47    15.47
             |
1 year <     |*****                       54   112    14.40    29.87
             |
2 years <    |*******************        193   305    51.47    81.33
             |
7 years <    |******                      61   366    16.27    97.60
             |
+ 12 years   |*                            9   375     2.40   100.00
             ----+---+---+---+---+
                40  80 120 160 200

                    Frequency
```

Question 8

FIM Experience

```
                                              Cum.            Cum.
                                        Freq  Freq  Percent  Percent
             |
< 1 year     |***********                 97    97    25.87    25.87
             |
1 year <     |******                      62   159    16.53    42.40
  2 years    |
2 years <    |****************           162   321    43.20    85.60
  7 years    |
7 years <    |*****                       50   371    13.33    98.93
  12 years   |
+ 12 years   |*                            4   375     1.07   100.00
             ----+---+---+---+-
                40  80 120 160

                  Frequency
```

Question 9

```
Training on FIMs                                  Cum.              Cum.
                                            Freq  Freq  Percent   Percent
                 |
ATC              |*******                    116   116   100.00    100.00
  Training       |
FTD              |*******************        291   291   100.00    100.00
  Training       |
OJT              |****************           251   251   100.00    100.00
                 |
Contractor       |*                           18    18   100.00    100.00
  Training       |
MAT              |******                     101   101   100.00    100.00
                 |
AMQP             |*****                       92    92   100.00    100.00
                 |
Other            |*                            9     9   100.00    100.00
                 ----+----+----+----+
                    75  150  225  300

                       Frequency
```

Question 10   Mean: 2.9

```
FIM Satisfaction                                  Cum.              Cum.
                                            Freq  Freq  Percent   Percent
      |
  1   |***                                    21    21     5.60      5.60
      |
  2   |*************                         103   124    27.47     33.07
      |
  3   |********************                  144   268    38.40     71.47
      |
  4   |*************                         103   371    27.47     98.93
      |
  5   |*                                       4   375     1.07    100.00
      ----+---+---+---+---+-
         30  60  90  120 150

              Frequency
```

```
Question 11      Mean:  2.6

FIM Accuracy                                   Cum.               Cum.
                                         Freq  Freq   Percent   Percent
           |
   1       |*********                      43    43     11.47     11.47
           |
   2       |**************************    133   176     35.47     46.93
           |
   3       |*************************     133   309     35.47     82.40
           |
   4       |************                   60   369     16.00     98.40
           |
   5       |*                               6   375      1.60    100.00
          ----+---+---+---+---+---+---
             20  40  60  80 100 120

                     Frequency
```

```
Question 12      Mean:  3.7

FIM Usefulness to New Technicians              Cum.               Cum.
                                         Freq  Freq   Percent   Percent
           |
   1       |*                               6     6      1.60      1.60
           |
   2       |***                            26    32      6.93      8.53
           |
   3       |***********                    86   118     22.93     31.47
           |
   4       |***************************   204   322     54.40     85.87
           |
   5       |******                         53   375     14.13    100.00
          ----+---+---+---+---+---+---+
             30  60  90 120 150 180 210

                        Frequency
```

Question 13   Mean: 3.4

```
FIM Usefulness-Experienced Technicians  Cum.              Cum.
                                  Freq  Freq  Percent  Percent
     |
  1  |*                              3     3     0.80     0.80
     |
  2  |***                           22    25     5.87     6.67
     |
  3  |*****************            113   138    30.13    36.80
     |
  4  |**************************** 201   339    53.60    90.40
     |
  5  |*****                         36   375     9.60   100.00
     ----+---+---+---+---+---+---+
        30  60  90 120 150 180 210

                Frequency
```

Question 14   Mean: 3.4

```
FIM Training                            Cum.              Cum.
                                  Freq  Freq  Percent  Percent
     |
  1  |**                            17    17     4.53     4.53
     |
  2  |*******                       48    65    12.80    17.33
     |
  3  |******************           112   177    29.87    47.20
     |
  4  |**************************** 175   352    46.67    93.87
     |
  5  |****                          23   375     6.13   100.00
     ----+---+---+---+---+---+---+
        25  50  75 100 125 150 175

               Frequency
```

```
Question 15      Mean:  3.6

FIM Usefulness in OJT                          Cum.              Cum.
                                         Freq  Freq   Percent   Percent
        |
   1    |*                                  7     7      1.87      1.87
        |
   2    |***                               25    32      6.67      8.53
        |
   3    |***************                  105   137     28.00     36.53
        |
   4    |***************************      199   336     53.07     89.60
        |
   5    |*****                             39   375     10.40    100.00
        ----+---+---+---+---+---+---+
           30  60  90 120 150 180 210

                  Frequency
```

```
Question 16      Mean:  2.4

FIM Accuracy                                   Cum.              Cum.
                                         Freq  Freq   Percent   Percent
        |
   1    |*********                         61    61     16.27     16.27
        |
   2    |***********************          149   210     39.73     56.00
        |
   3    |*********************            133   343     35.47     91.47
        |
   4    |*****                             30   373      8.00     99.47
        |
   5    |*                                  2   375      0.53    100.00
        ----+---+---+---+---+---+-
           25  50  75 100 125 150

                  Frequency
```

Question 17 Mean: 3.0

```
FIM Illustration Usefulness                       Cum.              Cum.
                                            Freq  Freq   Percent  Percent
    |
 1  |**                                       16    16      4.27     4.27
    |
 2  |*************                            78    94     20.80    25.07
    |
 3  |***************************             170   264     45.33    70.40
    |
 4  |****************                        103   367     27.47    97.87
    |
 5  |*                                         8   375      2.13   100.00
    ----+---+---+---+---+---+---+
       25  50  75 100 125 150 175

             Frequency
```

Question 18 Mean: 3.5

```
Need for more FIM Illustrations                   Cum.              Cum.
                                            Freq  Freq   Percent  Percent
    |
 1  |*                                         3     3      0.80     0.80
    |
 2  |***                                      22    25      5.87     6.67
    |
 3  |**************************              166   191     44.27    50.93
    |
 4  |**********************                  134   325     35.73    86.67
    |
 5  |********                                 50   375     13.33   100.00
    ----+---+---+---+---+---+---+
       25  50  75 100 125 150 175

             Frequency
```

```
Question 19     Mean:  3.0

Size Adequacy of FIM Illustrations          Cum.             Cum.
                                      Freq  Freq  Percent  Percent
        |
  1     |*                               8     8     2.13     2.13
        |
  2     |************                   89    97    23.73    25.87
        |
  3     |*************************     191   288    50.93    76.80
        |
  4     |**********                     72   360    19.20    96.00
        |
  5     |**                             15   375     4.00   100.00
        ----+---+---+---+---+---+-
           30  60  90 120 150 180

               Frequency
```

```
Question 20     Mean:  2.8

FIM Illustration Accuracy                   Cum.             Cum.
                                      Freq  Freq  Percent  Percent
        |
  1     |*                              12    12     3.20     3.20
        |
  2     |*****************             110   122    29.33    32.53
        |
  3     |**************************** 182   304    48.53    81.07
        |
  4     |**********                     67   371    17.87    98.93
        |
  5     |*                               4   375     1.07   100.00
        ---+---+---+---+---+---+---+-
          25  50  75 100 125 150 175

                   Frequency
```

Question 21   Mean: 3.1

```
FIM Illustration Usefulness                  Cum.              Cum.
                                       Freq  Freq  Percent  Percent
        |
  1     |**                              16    16     4.27     4.27
        |
  2     |*********                       61    77    16.27    20.53
        |
  3     |**************************** 179   256    47.73    68.27
        |
  4     |****************               109   365    29.07    97.33
        |
  5     |*                               10   375     2.67   100.00
        ---+---+---+---+---+---+---+-
          25  50  75 100 125 150 175

                 Frequency
```

Question 22   Mean: 2.7

```
FIM Fault Tree Illustration Accuracy         Cum.              Cum.
                                       Freq  Freq  Percent  Percent
        |
  1     |****                            31    31     8.27     8.27
        |
  2     |**************                 111   142    29.60    37.87
        |
  3     |************************       181   323    48.27    86.13
        |
  4     |*******                         50   373    13.33    99.47
        |
  5     |*                                2   375     0.53   100.00
        ----+---+---+---+---+---+-
           30  60  90 120 150 180

                Frequency
```

```
Question 23     Mean:  2.6

FIM Procedures Accuracy                          Cum.              Cum.
                                          Freq   Freq   Percent   Percent
           |
  1        |*****                            28     28      7.47      7.47
           |
  2        |*********************           135    163     36.00     43.47
           |
  3        |*************************** 167    330     44.53     88.00
           |
  4        |*******                          44    374     11.73     99.73
           |
  5        |*                                 1    375      0.27    100.00
           ----+---+---+---+---+---+---+
              25  50  75 100 125 150 175

                    Frequency
```

```
Question 24     Mean:  2.7

FIM Procedures Accuracy                          Cum.              Cum.
                                          Freq   Freq   Percent   Percent
           |
  1        |****                             27     27      7.20      7.20
           |
  2        |********************            126    153     33.60     40.80
           |
  3        |**************************      160    313     42.67     83.47
           |
  4        |**********                       61    374     16.27     99.73
           |
  5        |*                                 1    375      0.27    100.00
           ----+---+---+---+---+---+---+
              25  50  75 100 125 150 175

                    Frequency
```

Question 25 Mean: 3.5

FIM Procedures Usefulness

		Freq	Cum. Freq	Percent	Cum. Percent
1	*	6	6	1.60	1.60
2	****	32	38	8.53	10.13
3	****************	123	161	32.80	42.93
4	**************************	199	360	53.07	96.00
5	**	15	375	4.00	100.00

----+---+---+---+---+---+---

30 60 90 120 150 180

Frequency

Question 26 Mean: 2.7

FIM Procedures Usefulness

		Freq	Cum. Freq	Percent	Cum. Percent
1	*****	30	30	8.00	8.00
2	******************	111	141	29.60	37.60
3	**************************	163	304	43.47	81.07
4	***********	70	374	18.67	99.73
5	*	1	375	0.27	100.00

----+---+---+---+---+---+---+

25 50 75 100 125 150 175

Frequency

```
Question 27      Mean:  3.6

FIM Fault Tree Usefulness                      Cum.              Cum.
                                         Freq  Freq  Percent  Percent
      |
  1   |*                                    1     1     0.27     0.27
      |
  2   |**                                  16    17     4.27     4.53
      |
  3   |*******************                144   161    38.40    42.93
      |
  4   |**************************         195   356    52.00    94.93
      |
  5   |**                                  19   375     5.07   100.00
      ----+---+---+---+---+---+---+
         30  60  90 120 150 180 210

              Frequency
```

```
Question 28      Mean:  3.3

FIM Fault Tree Usefulness                      Cum.              Cum.
                                         Freq  Freq  Percent  Percent
      |
  1   |*                                    8     8     2.13     2.13
      |
  2   |*********                           54    62    14.40    16.53
      |
  3   |**************************         161   223    42.93    59.47
      |
  4   |*********************              133   356    35.47    94.93
      |
  5   |***                                 19   375     5.07   100.00
      ----+---+---+---+---+---+---+
         25  50  75 100 125 150 175

              Frequency
```

```
Question 29      Mean:   2.6

FIM Fault Tree Accuracy                                 Cum.              Cum.
                                                 Freq   Freq   Percent   Percent
       |
  1    |****                                       25     25      6.67      6.67
       |
  2    |***********************                   140    165     37.33     44.00
       |
  3    |***************************               166    331     44.27     88.27
       |
  4    |*******                                    40    371     10.67     98.93
       |
  5    |*                                           4    375      1.07    100.00
       ----+---+---+---+---+---+---+
          25  50  75  100 125 150 175

                 Frequency
```

```
Question 30      Mean:   2.6

FIM Fault Tree Accuracy                                 Cum.              Cum.
                                                 Freq   Freq   Percent   Percent
       |
  1    |****                                       27     27      7.20      7.20
       |
  2    |***********************                   138    165     36.80     44.00
       |
  3    |***************************               169    334     45.07     89.07
       |
  4    |******                                     40    374     10.67     99.73
       |
  5    |*                                           1    375      0.27    100.00
       ----+---+---+---+---+---+---+
          25  50  75  100 125 150 175

             Frequency
```

```
Question 31      Mean:  3.1

FIM Troubleshooting Usefulness                 Cum.              Cum.
                                        Freq   Freq   Percent   Percent
         |
  1      |***                            21     21      5.60      5.60
         |
  2      |**********                     62     83     16.53     22.13
         |
  3      |************************      150    233     40.00     62.13
         |
  4      |*********************         128    361     34.13     96.27
         |
  5      |**                             14    375      3.73    100.00
         ----+---+---+---+---+---+
            25  50  75  100 125 150

                 Frequency
```

```
Question 32      Mean:  3.3

FIM Troubleshooting Accuracy                   Cum.              Cum.
                                        Freq   Freq   Percent   Percent
         |
  1      |**                             12     12      3.20      3.20
         |
  2      |*********                      58     70     15.47     18.67
         |
  3      |***********************       144    214     38.40     57.07
         |
  4      |***********************       147    361     39.20     96.27
         |
  5      |**                             14    375      3.73    100.00
         ----+---+---+---+---+---+
            25  50  75  100 125 150

                 Frequency
```

Question 33 Mean: 3.1

FIM Troubleshooting Accuracy

		Freq	Cum. Freq	Percent	Cum. Percent
1	*	6	6	1.60	1.60
2	**********	68	74	18.13	19.73
3	***************************	174	248	46.40	66.13
4	*******************	120	368	32.00	98.13
5	*	7	375	1.87	100.00

```
----+---+---+---+---+---+---+
   25  50  75 100 125 150 175

           Frequency
```

Question 34 Mean: 2.8

FIM Troubleshooting Usefulness

		Freq	Cum. Freq	Percent	Cum. Percent
1	***	21	21	5.60	5.60
2	*******************	119	140	31.73	37.33
3	****************************	175	315	46.67	84.00
4	********	49	364	13.07	97.07
5	**	11	375	2.93	100.00

```
----+---+---+---+---+---+---+
   25  50  75 100 125 150 175

           Frequency
```

```
Question 35     Mean:  3.5

FIM Index Usefulness                            Cum.               Cum.
                                          Freq  Freq  Percent   Percent
           |
   1       |*                                2     2     0.53      0.53
           |
   2       |***                             20    22     5.33      5.87
           |
   3       |********************           148   170    39.47     45.33
           |
   4       |**************************     192   362    51.20     96.53
           |
   5       |**                              13   375     3.47    100.00
           ----+---+---+---+---+---+---+
               30  60  90  120 150 180 210

                     Frequency
```

```
Question 36     Mean:  3.4

FIM Index Accuracy                              Cum.               Cum.
                                          Freq  Freq  Percent   Percent
           |
   1       |*                                3     3     0.80      0.80
           |
   2       |******                          38    41    10.13     10.93
           |
   3       |***************************    169   210    45.07     56.00
           |
   4       |************************       153   363    40.80     96.80
           |
   5       |**                              12   375     3.20    100.00
           ----+---+---+---+---+---+---+
               25  50  75  100 125 150 175

                     Frequency
```

Question 37 Mean: 2.7

Receipt of Fault Code

		Freq	Cum. Freq	Percent	Cum. Percent
1	*****	35	35	9.33	9.33
2	*****************	114	149	30.40	39.73
3	**********************	146	295	38.93	78.67
4	************	76	371	20.27	98.93
5	*	4	375	1.07	100.00

```
----+---+---+---+---+---+
   25  50  75 100 125 150
```

Frequency

Question 38 Mean: 2.8

Fault Code Accuracy

		Freq	Cum. Freq	Percent	Cum. Percent
1	*****	29	29	7.73	7.73
2	****************	101	130	26.93	34.67
3	************************	161	291	42.93	77.60
4	**************	81	372	21.60	99.20
5	*	3	375	0.80	100.00

```
----+---+---+---+---+---+-
   25  50  75 100 125 150
```

Frequency

Question 39 Mean: 2.7

```
Fault Code Accuracy                                 Cum.               Cum.
                                              Freq  Freq   Percent   Percent
     |
  1  |****                                      26    26      6.93      6.93
     |
  2  |********************                     124   150     33.07     40.00
     |
  3  |*************************** 173          323   46.13     86.13
     |
  4  |********                                  52   375     13.87    100.00
     |
  5  |                                           0   375      0.00    100.00
     ----+---+---+---+---+---+---+
        25  50  75 100 125 150 175

                 Frequency
```

NOTE: QUESTIONS 40 THROUGH 44 OF THE SURVEY WERE REVERSE CODED QUESTIONS FOR TESTING THE RELIABILITY OF THE ANSWERS. AS SUCH, THEIR RESPONSES ARE NOT CRITICAL TO THE RESEARCH EFFORT AND ARE NOT REPORTED.

Question 45

```
FIM Use                                             Cum.               Cum.
                                              Freq  Freq   Percent   Percent
                 |
0 - 25 percent   |*****************            132   132     35.20     35.20
                 |
26 - 50 percent  |***********                   87   219     23.20     58.40
                 |
51 - 75 percent  |***********                   87   306     23.20     81.60
                 |
76 - 100 percent |*********                     68   374     18.40    100.00
                 ----+---+---+---+-
                    30  60  90 120

                       Frequency
```

Question 46

```
Most Useful FIM Element                    Cum.              Cum.
                                     Freq  Freq   Percent   Percent
                 |
Fault Trees      |******************  140   140    37.43     37.43
                 |
Simplicity       |**                   19   159     5.08     42.51
                 |
Step-by-Step     |*****************   134   293    35.83     78.34
 Procedures      |
Illustrations    |******               41   334    10.96     89.30
                 |
Indexes          |*                    11   345     2.94     92.25
                 |
Other            |****                 29   374     7.75    100.00
                 ----+---+---+---+---+
                    30  60  90 120 150

                       Frequency
```

Question 47

```
Least Useful FIM Element                   Cum.              Cum.
                                     Freq  Freq   Percent   Percent
                 |
Fault Trees      |*********            47    47    12.60     12.60
                 |
Simplicity       |**************       72   119    19.30     31.90
                 |
Step by Step     |********             38   157    10.19     42.09
  Procedures     |
Illustrations    |***************      76   233    20.38     62.47
                 |
Indexes          |*****************    84   317    22.52     84.99
                 |
Other            |***********          56   373    15.01    100.00
                 ----+---+---+---+-
                    20  40  60  80

                     Frequency
```

Question 48

FIM Error Reporting

		Freq	Cum. Freq	Percent	Cum. Percent
Tell Supervisor	*******************	118	118	31.55	31.55
AFTO 22	****************	104	222	27.81	59.36
Ignore	******	39	261	10.43	69.79
No Errors Seen	*************	81	342	21.66	91.44
Other	*****	32	374	8.56	100.00

```
----+---+---+---+---+
   25  50  75  100 125
```

Frequency

Question 49

FIM Improvement

		Freq	Cum. Freq	Percent	Cum. Percent
Improve Illustrations	****	27	27	7.22	7.22
More Step-by-Step Procedure	*****	30	57	8.02	15.24
Fault Tree Accuracy	*****************	108	165	28.88	44.12
Improve Proc for fault isol.	***************	90	255	24.06	68.18
Improve Index	***	20	275	5.35	73.53
Improve Training	**************	72	347	19.25	92.78
Other	*****	27	374	7.22	100.00

```
----+---+---+---+-
   25  50  75  100
```

Frequency

Question 50

```
Other Fault Isolation Methods               Cum.                Cum.
                                     Freq   Freq   Percent   Percent
                 |
Approved QA      |*****               102    102     99.03     99.03
 Procedures      |
Experience       |****************    261    261    100.00    100.00
                 |
Contractor       |***                  68     68    100.00    100.00
  Data           |
Cheat Sheets     |***                  65     65    100.00    100.00
                 |
Other            |**                   53     53    100.00    100.00
                 ----+----+----+----+
                    75  150  225  300

                       Frequency
```

Appendix C: FIM Use By Demographic Data

TABLE OF GRADE BY FIMUSE

GRADE(grade of technicians)

FIMUSE

Frequency / Percent / Row Pct / Col Pct	0 - 25 percent	26 - 50 percent	51 - 75 percent	76 - 100 percent	Total
E1/E2/E3	34	19	19	11	83
	9.09	5.08	5.08	2.94	22.19
	40.96	22.89	22.89	13.25	
	25.76	21.84	21.84	16.18	
E4	38	22	26	21	107
	10.16	5.88	6.95	5.61	28.61
	35.51	20.56	24.30	19.63	
	28.79	25.29	29.89	30.88	
E5	44	31	22	22	119
	11.76	8.29	5.88	5.88	31.82
	36.97	26.05	18.49	18.49	
	33.33	35.63	25.29	32.35	
E6	13	11	15	9	48
	3.48	2.94	4.01	2.41	12.83
	27.08	22.92	31.25	18.75	
	9.85	12.64	17.24	13.24	
E7/E8	3	4	5	5	17
	0.80	1.07	1.34	1.34	4.55
	17.65	23.53	29.41	29.41	
	2.27	4.60	5.75	7.35	
Total	132	87	87	68	374
	35.29	23.26	23.26	18.18	100.00

TABLE OF AFSC BY FIMUSE

AFSC(afsc of technicians)

FIMUSE

Frequency / Percent / Row Pct / Col Pct	0 - 25 percent	26 - 50 percent	51 - 75 percent	76 - 100 percent	Total
452X4B	65 17.38 43.05 49.24	27 7.22 17.88 31.03	33 8.82 21.85 37.93	26 6.95 17.22 38.24	151 40.37
452X2B	4 1.07 16.00 3.03	10 2.67 40.00 11.49	8 2.14 32.00 9.20	3 0.80 12.00 4.41	25 6.68
462X0	27 7.22 24.77 20.45	26 6.95 23.85 29.89	30 8.02 27.52 34.48	26 6.95 23.85 38.24	109 29.14
452X5	5 1.34 16.13 3.79	12 3.21 38.71 13.79	9 2.41 29.03 10.34	5 1.34 16.13 7.35	31 8.29
452X2C	13 3.48 72.22 9.85	2 0.53 11.11 2.30	1 0.27 5.56 1.15	2 0.53 11.11 2.94	18 4.81
452X2A	4 1.07 25.00 3.03	4 1.07 25.00 4.60	4 1.07 25.00 4.60	4 1.07 25.00 5.88	16 4.28
45272	14 3.74 58.33 10.61	6 1.60 25.00 6.90	2 0.53 8.33 2.30	2 0.53 8.33 2.94	24 6.42
Total	132 35.29	87 23.26	87 23.26	68 18.18	374 100.00

TABLE OF SKILL BY FIMUSE

SKILL(skill level of technicians)

FIMUSE

Frequency / Percent / Row Pct / Col Pct	0 - 25 percent	26 - 50 percent	51 - 75 percent	76 - 100 percent	Total
3	23 6.15 46.94 17.42	11 2.94 22.45 12.64	8 2.14 16.33 9.20	7 1.87 14.29 10.29	49 13.10
5	55 14.71 34.81 41.67	37 9.89 23.42 42.53	38 10.16 24.05 43.68	28 7.49 17.72 41.18	158 42.25
7 and 9	54 14.44 32.34 40.91	39 10.43 23.35 44.83	41 10.96 24.55 47.13	33 8.82 19.76 48.53	167 44.65
Total	132 35.29	87 23.26	87 23.26	68 18.18	374 100.00

TABLE OF BASE BY FIMUSE

BASE(base of technicians)

FIMUSE

Frequency / Percent / Row Pct / Col Pct	0 - 25 percent	26 - 50 percent	51 - 75 percent	76 - 100 percent	Total
Homestead	29 7.73 46.77 21.97	13 3.47 20.97 14.94	12 3.20 19.35 13.79	9 2.13 12.90 11.59	63 16.53
Shaw	29 7.73 42.03 21.97	17 4.53 24.64 19.54	12 3.20 17.39 13.79	11 2.93 15.94 15.94	69 18.40
MacDill	25 6.67 32.89 18.94	15 4.00 19.74 17.24	26 6.93 34.21 29.89	10 2.67 13.16 14.49	76 20.27
Luke	17 4.53 24.29 12.88	19 5.07 27.14 21.84	17 4.53 24.29 19.54	17 4.53 24.29 24.64	70 18.67
Moody	9 2.40 18.37 6.82	14 3.73 28.57 16.09	14 3.73 28.57 16.09	12 3.20 24.49 17.39	49 13.07
Hill	23 6.13 47.92 17.42	9 2.40 18.75 10.34	6 1.60 12.50 6.90	10 2.67 20.83 14.49	48 12.80
Total	132 35.20	87 23.20	87 23.20	69 18.40	375 100.00

TABLE OF MXEXP BY FIMUSE

MXEXP(Mainteance Experience of Technicians)

FIMUSE

Frequency / Percent / Row Pct / Col Pct	0 - 25 percent	26 - 50 percent	51 - 75 percent	76 - 100 percent	Total
less than 2 year	29 7.73 43.94 21.97	14 3.73 21.21 16.09	11 2.93 16.67 12.64	12 3.20 18.18 17.39	66 17.60
2 years < 7 year	42 11.20 32.31 31.82	29 7.73 22.31 33.33	37 9.87 28.46 42.53	22 5.87 16.92 31.88	130 34.67
7 years or more	61 16.27 34.08 46.21	44 11.73 24.58 50.57	39 10.40 21.79 44.83	35 9.33 19.55 50.72	179 47.73
Total	132 35.20	87 23.20	87 23.20	69 18.40	375 100.00

TABLE OF F16EXP BY FIMUSE

F16EXP(F-16 Experience of Technicians)

FIMUSE

Frequency / Percent / Row Pct / Col Pct	0 - 25 percent	26 - 50 percent	51 - 75 percent	76 - 100 percent	Total
less than 2 year	42 11.20 37.50 31.82	22 5.87 19.64 25.29	23 6.13 20.54 26.44	25 6.67 22.32 36.23	112 29.87
2 years < 7 year	62 16.53 32.12 46.97	47 12.53 24.35 54.02	49 13.07 25.39 56.32	35 9.33 18.13 50.72	193 51.47
7 years or more	28 7.47 40.00 21.21	18 4.80 25.71 20.69	15 4.00 21.43 17.24	9 2.40 12.86 13.04	70 18.67
Total	132 35.20	87 23.20	87 23.20	69 18.40	375 100.00

TABLE OF FIMEXP BY FIMUSE

FIMEXP(FIM Experience by Technicians)

Frequency Percent Row Pct Col Pct	FIMUSE 0 - 25 percent	26 - 50 percent	51 - 75 percent	76 - 100 percent	Total
less than 2 year	67 17.87 42.14 50.76	27 7.20 16.98 31.03	33 8.80 20.75 37.93	32 8.53 20.13 46.38	159 42.40
2 years < 7 year	44 11.73 27.16 33.33	48 12.80 29.63 55.17	39 10.40 24.07 44.83	31 8.27 19.14 44.93	162 43.20
7 years or more	21 5.60 38.89 15.91	12 3.20 22.22 13.79	15 4.00 27.78 17.24	6 1.60 11.11 8.70	54 14.40
Total	132 35.20	87 23.20	87 23.20	69 18.40	375 100.00

Appendix D: Most Useful FIM Feature Response By Demographic Data

TABLE OF GRADE BY USEFUL AREA

GRADE(grade of technicians)

BESTAREA

Frequency / Percent / Row Pct / Col Pct	Fault Trees	Simplicity	Step by Step Pro
E1/E2/E3	25 6.70 30.49 17.99	3 0.80 3.66 15.79	30 8.04 36.59 22.39
E4	45 12.06 42.06 32.37	6 1.61 5.61 31.58	36 9.65 33.64 26.87
E5	47 12.60 39.50 33.81	4 1.07 3.36 21.05	42 11.26 35.29 31.34
E6	17 4.56 35.42 12.23	4 1.07 8.33 21.05	19 5.09 39.58 14.18
E7/E8	5 1.34 29.41 3.60	2 0.54 11.76 10.53	7 1.88 41.18 5.22
Total	139 37.27	19 5.09	134 35.92

(Continued)

TABLE OF GRADE BY USEFUL AREA

GRADE(grade of technicians)
BESTAREA

Frequency / Percent / Row Pct / Col Pct	Illustrations	Indexes	Other	Total
E1/E2/E3	10 2.68 12.20 24.39	3 0.80 3.66 27.27	11 2.95 13.41 37.93	82 21.98
E4	10 2.68 9.35 24.39	4 1.07 3.74 36.36	6 1.61 5.61 20.69	107 28.69
E5	14 3.75 11.76 34.15	3 0.80 2.52 27.27	9 2.41 7.56 31.03	119 31.90
E6	6 1.61 12.50 14.63	0 0.00 0.00 0.00	2 0.54 4.17 6.90	48 12.87
E7/E8	1 0.27 5.88 2.44	1 0.27 5.88 9.09	1 0.27 5.88 3.45	17 4.56
Total	41 10.99	11 2.95	29 7.77	373 100.00

TABLE OF AFSC BY USEFUL AREA

AFSC(afsc of technicians) BESTAREA

Frequency / Percent / Row Pct / Col Pct	Fault Trees	Simplicity	Step by Step Pro
452X4B	44	5	72
	11.80	1.34	19.30
	29.14	3.31	47.68
	31.65	26.32	53.73
452X2B	7	2	4
	1.88	0.54	1.07
	29.17	8.33	16.67
	5.04	10.53	2.99
462X0	52	4	33
	13.94	1.07	8.85
	47.71	3.67	30.28
	37.41	21.05	24.63
452X5	11	2	13
	2.95	0.54	3.49
	35.48	6.45	41.94
	7.91	10.53	9.70
452X2C	10	1	6
	2.68	0.27	1.61
	55.56	5.56	33.33
	7.19	5.26	4.48
452X2A	5	3	5
	1.34	0.80	1.34
	31.25	18.75	31.25
	3.60	15.79	3.73
45272	10	2	1
	2.68	0.54	0.27
	41.67	8.33	4.17
	7.19	10.53	0.75
Total	139	19	134
	37.27	5.09	35.92

(Continued)

TABLE OF AFSC BY USEFUL AREA

AFSC(afsc of technic[Aians)
BESTAREA

Frequency / Percent / Row Pct / Col Pct	Illustrations	Indexes	Other	Total
452X4B	11	2	17	151
	2.95	0.54	4.56	40.48
	7.28	1.32	11.26	
	26.83	18.18	58.62	
452X2B	7	1	3	24
	1.88	0.27	0.80	6.43
	29.17	4.17	12.50	
	17.07	9.09	10.34	
462X0	10	6	4	109
	2.68	1.61	1.07	29.22
	9.17	5.50	3.67	
	24.39	54.55	13.79	
452X5	2	1	2	31
	0.54	0.27	0.54	8.31
	6.45	3.23	6.45	
	4.88	9.09	6.90	
452X2C	1	0	0	18
	0.27	0.00	0.00	4.83
	5.56	0.00	0.00	
	2.44	0.00	0.00	
452X2A	1	1	1	16
	0.27	0.27	0.27	4.29
	6.25	6.25	6.25	
	2.44	9.09	3.45	
45272	9	0	2	24
	2.41	0.00	0.54	6.43
	37.50	0.00	8.33	
	21.95	0.00	6.90	
Total	41	11	29	373

TABLE OF SKILL BY USEFUL AREA

SKILL(skill level of technicians)

BESTAREA

Frequency / Percent / Row Pct / Col Pct	Fault Trees	Simplicity	Step by Step Pro
3	16 4.29 33.33 11.51	1 0.27 2.08 5.26	19 5.09 39.58 14.18
5	62 16.62 39.24 44.60	8 2.14 5.06 42.11	51 13.67 32.28 38.06
7 and 9	61 16.35 36.53 43.88	10 2.68 5.99 52.63	64 17.16 38.32 47.76
Total	139 37.27	19 5.09	134 35.92

(Continued)

TABLE OF SKILL BY USEFUL AREA

SKILL(skill level of technicians)

BESTAREA

Frequency / Percent / Row Pct / Col Pct	Illustrations	Indexes	Other	Total
3	4	3	5	48
	1.07	0.80	1.34	12.87
	8.33	6.25	10.42	
	9.76	27.27	17.24	
5	20	5	12	158
	5.36	1.34	3.22	42.36
	12.66	3.16	7.59	
	48.78	45.45	41.38	
7 and 9	17	3	12	167
	4.56	0.80	3.22	44.77
	10.18	1.80	7.19	
	41.46	27.27	41.38	
Total	41	11	29	373
	10.99	2.95	7.77	100.00

TABLE OF BASE BY USEFUL AREA

BASE(base of technicians)

Frequency / Percent / Row Pct / Col Pct	BESTAREA: Fault Trees	Simplicity	Step by Step Pro
Homestead	20	1	21
	5.35	0.27	5.61
	32.26	1.61	33.87
	14.29	5.26	15.67
Shaw	27	6	18
	7.22	1.60	4.81
	39.13	8.70	26.09
	19.29	31.58	13.43
MacDill	31	4	27
	8.29	1.07	7.22
	41.33	5.33	36.00
	22.14	21.05	20.15
Luke	27	3	28
	7.22	0.80	7.49
	38.57	4.29	40.00
	19.29	15.79	20.90
Moody	19	4	23
	5.08	1.07	6.15
	38.78	8.16	46.94
	13.57	21.05	17.16
Hill	15	1	17
	4.01	0.27	4.55
	31.25	2.08	35.42
	10.71	5.26	12.69
Total	140	19	134
	37.43	5.08	35.83

(Continued)

TABLE OF BASE BY USEFUL AREA

BASE(base of technicians)   BESTAREA

Frequency Percent Row Pct Col Pct	Illustrations	Indexes	Other	Total
Homestead	10 2.67 16.13 24.39	4 1.07 6.45 36.36	6 1.60 9.68 20.69	62 16.58
Shaw	11 2.94 15.94 26.83	2 0.53 2.90 18.18	5 1.34 7.25 17.24	69 18.45
MacDill	4 1.07 5.33 9.76	3 0.80 4.00 27.27	6 1.60 8.00 20.69	75 20.05
Luke	8 2.14 11.43 19.51	0 0.00 0.00 0.00	4 1.07 5.71 13.79	70 18.72
Moody	2 0.53 4.08 4.88	0 0.00 0.00 0.00	1 0.27 2.04 3.45	49 13.10
Hill	6 1.60 12.50 14.63	2 0.53 4.17 18.18	7 1.87 14.58 24.14	48 12.83
Total	41 10.96	11 2.94	29 7.75	374 100.00

TABLE OF MXEXP BY USEFUL AREA

MXEXP(Mainteance Experience of Technicians)

Frequency / Percent / Row Pct / Col Pct	BESTAREA: Fault Trees	Simplicity	Step by Step Pro
less than 2 year	18 4.81 27.69 12.86	2 0.53 3.08 10.53	27 7.22 41.54 20.15
2 years < 7 year	58 15.51 44.62 41.43	7 1.87 5.38 36.84	39 10.43 30.00 29.10
7 years or more	64 17.11 35.75 45.71	10 2.67 5.59 52.63	68 18.18 37.99 50.75
Total	140 37.43	19 5.08	134 35.83

(Continued)

TABLE OF MXEXP BY USEFUL AREA

MXEXP(Mainteance Experience of Technicians)

BESTAREA

Frequency Percent Row Pct Col Pct	Illustrations	Indexes	Other	Total
less than 2 year	6 1.60 9.23 14.63	3 0.80 4.62 27.27	9 2.41 13.85 31.03	65 17.38
2 years < 7 year	13 3.48 10.00 31.71	5 1.34 3.85 45.45	8 2.14 6.15 27.59	130 34.76
7 years or more	22 5.88 12.29 53.66	3 0.80 1.68 27.27	12 3.21 6.70 41.38	179 47.86
Total	41 10.96	11 2.94	29 7.75	374 100.00

TABLE OF F16EXP BY USEFUL AREA

F16EXP(F-16 Experience of Technicians)

BESTAREA

Frequency Percent Row Pct Col Pct	Fault. Trees	Simplicity	Step by Step Pro
less than 2 year	37 9.89 33.33 26.43	5 1.34 4.50 26.32	45 12.03 40.54 33.58
2 years < 7 year	77 20.59 39.90 55.00	12 3.21 6.22 63.16	64 17.11 33.16 47.76
7 years or more	26 6.95 37.14 18.57	2 0.53 2.86 10.53	25 6.68 35.71 18.66
Total	140 37.43	19 5.08	134 35.83

(Continued)

TABLE OF F16EXP BY USEFUL AREA

F16EXP(F-16 Experience of Technicians)

BESTAREA

Frequency / Percent / Row Pct / Col Pct	Illustrations	Indexes	Other	Total
less than 2 year	7 1.87 6.31 17.07	4 1.07 3.60 36.36	13 3.48 11.71 44.83	111 29.68
2 years < 7 year	22 5.88 11.40 53.66	7 1.87 3.63 63.64	11 2.94 5.70 37.93	193 51.60
7 years or more	12 3.21 17.14 29.27	0 0.00 0.00 0.00	5 1.34 7.14 17.24	70 18.72
Total	41 10.96	11 2.94	29 7.75	374 100.00

TABLE OF FIMEXP BY USEFUL AREA

FIMEXP(FIM Experience by Technicians)

Frequency / Percent / Row Pct / Col Pct	BESTAREA: Fault - Trees	Simplicity	Step by Step Pro
less than 2 year	57	6	63
	15.24	1.60	16.84
	36.08	3.80	39.87
	40.71	31.58	47.01
2 years < 7 year	63	11	54
	16.84	2.94	14.44
	38.89	6.79	33.33
	45.00	57.89	40.30
7 years or more	20	2	17
	5.35	0.53	4.55
	37.04	3.70	31.48
	14.29	10.53	12.69
Total	140	19	134
	37.43	5.08	35.83

(Continued)

TABLE OF FIMEXP BY USEFUL AREA

FIMEXP(FIM Experience by Technicians)

BESTAREA

Frequency / Percent / Row Pct / Col Pct	Illustrations	Indexes	Other	Total
less than 2 year	10 2.67 6.33 24.39	5 1.34 3.16 45.45	17 4.55 10.76 58.62	158 42.25
2 years < 7 year	20 5.35 12.35 48.78	6 1.60 3.70 54.55	8 2.14 4.94 27.59	162 43.32
7 years or more	11 2.94 20.37 26.83	0 0.00 0.00 0.00	4 1.07 7.41 13.79	54 14.44
Total	41 10.96	11 2.94	29 7.75	374 100.00

Appendix E. Least Useful FIM Feature Response By Demographic Data

TABLE OF GRADE BY LEAST USEFUL AREA

GRADE(grade of technicians)

GRADE	WORSAREA: Fault Trees	WORSAREA: Simplicity	WORSAREA: Step by Step Pro
Frequency / Percent / Row Pct / Col Pct			
E1/E2/E3	10	17	8
	2.69	4.57	2.15
	12.35	20.99	9.88
	21.28	23.61	21.05
E4	11	18	10
	2.96	4.84	2.69
	10.28	16.82	9.35
	23.40	25.00	26.32
E5	15	20	15
	4.03	5.38	4.03
	12.61	16.81	12.61
	31.91	27.78	39.47
E6	7	16	4
	1.88	4.30	1.08
	14.58	33.33	8.33
	14.89	22.22	10.53
E7/E7	4	1	1
	1.08	0.27	0.27
	23.53	5.88	5.88
	8.51	1.39	2.63
Total	47	72	38
	12.63	19.35	10.22

(Continued)

TABLE OF GRADE BY LEAST USEFUL AREA

GRADE(grade of technicians)
WORSAREA

Frequency / Percent / Row Pct / Col Pct	Illustrations	Indexes	Other	Total
E1/E2/E3	16 4.30 19.75 21.05	17 4.57 20.99 20.48	13 3.49 16.05 23.21	81 21.77
E4	21 5.65 19.63 27.63	30 8.06 28.04 36.14	17 4.57 15.89 30.36	107 28.76
E5	28 7.53 23.53 36.84	25 6.72 21.01 30.12	16 4.30 13.45 28.57	119 31.99
E6	7 1.88 14.58 9.21	6 1.61 12.50 7.23	8 2.15 16.67 14.29	48 12.90
E7/E8	4 1.08 23.53 5.26	5 1.34 29.41 6.02	2 0.54 11.76 3.57	17 4.57
Total	76 20.43	83 22.31	56 15.05	372 100.00

TABLE OF AFSC BY LEAST USEFUL AREA

AFSC(afsc of technicians)

WORSAREA

Frequency / Percent / Row Pct / Col Pct	Fault Trees	Simplicity	Step by Step Pro
452X4B	13 3.49 8.67 27.66	25 6.72 16.67 34.72	11 2.96 7.33 28.95
452X2B	3 0.81 12.50 6.38	2 0.54 8.33 2.78	1 0.27 4.17 2.63
462X0	11 2.96 10.09 23.40	28 7.53 25.69 38.89	14 3.76 12.84 36.84
452X5	5 1.34 16.13 10.64	7 1.88 22.58 9.72	4 1.08 12.90 10.53
452X2C	1 0.27 5.56 2.13	4 1.08 22.22 5.56	1 0.27 5.56 2.63
452X2A	4 1.08 25.00 8.51	3 0.81 18.75 4.17	3 0.81 18.75 7.89
45272	10 2.69 41.67 21.28	3 0.81 12.50 4.17	4 1.08 16.67 10.53
Total	47 12.63	72 19.35	38 10.22

(Continued)

TABLE OF AFSC BY LEAST USEFUL AREA

AFSC(afsc of technicians)

WORSAREA

Frequency / Percent / Row Pct / Col Pct	Illustrations	Indexes	Other	Total
452X4B	38 10.22 25.33 50.00	29 7.80 19.33 34.94	34 9.14 22.67 60.71	150 40.32
452X2B	5 1.34 20.83 6.58	10 2.69 41.67 12.05	3 0.81 12.50 5.36	24 6.45
462X0	19 5.11 17.43 25.00	26 6.99 23.85 31.33	11 2.96 10.09 19.64	109 29.30
452X5	5 1.34 16.13 6.58	7 1.88 22.58 8.43	3 0.81 9.68 5.36	31 8.33
452X2C	5 1.34 27.78 6.58	5 1.34 27.78 6.02	2 0.54 11.11 3.57	18 4.84
452X2A	1 0.27 6.25 1.32	3 0.81 18.75 3.61	2 0.54 12.50 3.57	16 4.30
45272	3 0.81 12.50 3.95	3 0.81 12.50 3.61	1 0.27 4.17 1.79	24 6.45
Total	76 20.43	83 22.31	56 15.05	372 100.00

TABLE OF SKILL BY LEAST USEFUL AREA

SKILL(skill level of technicians)

WORSAREA

Frequency Percent Row Pct Col Pct	Fault Trees	Simplicity	Step by Step Pro
3	5 1.34 10.64 10.64	11 2.96 23.40 15.28	4 1.08 8.51 10.53
5	17 4.57 10.76 36.17	28 7.53 17.72 38.89	16 4.30 10.13 42.11
7 and 9	25 6.72 14.97 53.19	33 8.87 19.76 45.83	18 4.84 10.78 47.37
Total	47 12.63	72 19.35	38 10.22

(Continued)

TABLE OF SKILL BY LEAST USEFUL ARE

SKILL(skill level of technicians)

WORSAREA

Frequency / Percent / Row Pct / Col Pct	Illustrations	Indexes	Other	Total
3	7 1.88 14.89 9.21	12 3.23 25.53 14.46	8 2.15 17.02 14.29	47 12.63
5	32 8.60 20.25 42.11	42 11.29 26.58 50.60	23 6.18 14.56 41.07	158 42.47
7 and 9	37 9.95 22.16 48.68	29 7.80 17.37 34.94	25 6.72 14.97 44.64	167 44.89
Total	76 20.43	83 22.31	56 15.05	372 100.00

TABLE OF BASE BY LEAST USEFUL AREA

BASE(base of technicians)

WORSAREA

Frequency / Percent / Row Pct / Col Pct	Fault Trees	Simplicity	Step by Step Pro
Homestead	11 2.95 18.03 23.40	8 2.14 13.11 11.11	8 2.14 13.11 21.05
Shaw	7 1.88 10.14 14.89	14 3.75 20.29 19.44	12 3.22 17.39 31.58
MacDill	5 1.34 6.67 10.64	13 3.49 17.33 18.06	6 1.61 8.00 15.79
Luke	12 3.22 17.14 25.53	14 3.75 20.00 19.44	2 0.54 2.86 5.26
Moody	2 0.54 4.08 4.26	12 3.22 24.49 16.67	6 1.61 12.24 15.79
Hill	10 2.68 20.83 21.28	11 2.95 22.92 15.28	4 1.07 8.33 10.53
Total	47 12.60	72 19.30	38 10.19

(Continued)

TABLE OF BASE BY LEAST USEFUL AREA

BASE(base of technicians)

WORSAREA

Frequency Percent Row Pct Col Pct	Illustrations	Indexes	Other	Total
Homestead	11 2.95 18.03 14.47	12 3.22 19.67 14.29	11 2.95 18.03 19.64	61 16.35
Shaw	10 2.68 14.49 13.16	17 4.56 24.64 20.24	9 2.41 13.04 16.07	69 18.50
MacDill	16 4.29 21.33 21.05	19 5.09 25.33 22.62	16 4.29 21.33 28.57	75 20.11
Luke	19 5.09 27.14 25.00	15 4.02 21.43 17.86	8 2.14 11.43 14.29	70 18.77
Moody	12 3.22 24.49 15.79	12 3.22 24.49 14.29	5 1.34 10.20 8.93	49 13.14
Hill	8 2.14 16.67 10.53	8 2.14 16.67 9.52	7 1.88 14.58 12.50	48 12.87
Total	76 20.38	84 22.52	56 15.01	373 100.00

TABLE OF MXEXP BY LEAST USEFUL AREA

MXEXP(Mainteance Experience of Technicians)

WORSAREA

Frequency Percent Row Pct Col Pct	Fault Trees	Simplicity	Step by Step Pro
less than 2 year	10 2.68 15.63 21.28	16 4.29 25.00 22.22	6 1.61 9.38 15.79
2 years < 7 year	10 2.68 7.69 21.28	22 5.90 16.92 30.56	12 3.22 9.23 31.58
7 years or more	27 7.24 15.08 57.45	34 9.12 18.99 47.22	20 5.36 11.17 52.63
Total	47 12.60	72 19.30	38 10.19

(Continued)

TABLE OF MXEXP BY LEAST USEFUL AREA

MXEXP(Mainteance Experience of Technicians)

WORSAREA

Frequency Percent Row Pct Col Pct	Illustrations	Indexes	Other	Total
less than 2 year	8 2.14 12.50 10.53	12 3.22 18.75 14.29	12 3.22 18.75 21.43	64 17.16
2 years < 7 year	30 8.04 23.08 39.47	40 10.72 30.77 47.62	16 4.29 12.31 28.57	130 34.85
7 years or more	38 10.19 21.23 50.00	32 8.58 17.88 38.10	28 7.51 15.64 50.00	179 47.99
Total	76 20.38	84 22.52	56 15.01	373 100.00

TABLE OF F16EXP BY LEAST USEFUL AREA

F16EXP(F-16 Experience of Technicians)

WORSAREA

Frequency Percent Row Pct Col Pct	Fault-Trees	Simplicity	Step by Step Pro
less than 2 year	12 3.22 10.91 25.53	23 6.17 20.91 31.94	6 1.61 5.45 15.79
2 years < 7 year	23 6.17 11.92 48.94	35 9.38 18.13 48.61	26 6.97 13.47 68.42
7 years or more	12 3.22 17.14 25.53	14 3.75 20.00 19.44	6 1.61 8.57 15.79
Total	47 12.60	72 19.30	38 10.19

(Continued)

TABLE OF F16EXP BY LEAST USEFUL AREA

F16EXP(F-16 Experience of Technicians)

Frequency / Percent / Row Pct / Col Pct	WORSAREA: Illustrations	Indexes	Other	Total
less than 2 year	21 5.63 19.09 27.63	26 6.97 23.64 30.95	22 5.90 20.00 39.29	110 29.49
2 years < 7 year	43 11.53 22.28 56.58	45 12.06 23.32 53.57	21 5.63 10.88 37.50	193 51.74
7 years or more	12 3.22 17.14 15.79	13 3.49 18.57 15.48	13 3.49 18.57 23.21	70 18.77
Total	76 20.38	84 22.52	56 15.01	373 100.00

TABLE OF FIMEXP BY LEAST USEFUL AREA

FIMEXP(FIM Experience by Technicians)

WORSAREA

Frequency / Percent / Row Pct / Col Pct	Fault Trees	Simplicity	Step by Step Pro
less than 2 year	15 4.02 9.55 31.91	36 9.65 22.93 50.00	9 2.41 5.73 23.68
2 years < 7 year	22 5.90 13.58 46.81	26 6.97 16.05 36.11	23 6.17 14.20 60.53
7 years or more	10 2.68 18.52 21.28	10 2.68 18.52 13.89	6 1.61 11.11 15.79
Total	47 12.60	72 19.30	38 10.19

(Continued)

TABLE OF FIMEXP BY LEAST USEFUL AREA

FIMEXP(FIM Experience by Technicians)

Frequency / Percent / Row Pct / Col Pct	WORSAREA: Illustrations	Indexes	Other	Total
less than 2 year	32	34	31	157
	8.58	9.12	8.31	42.09
	20.38	21.66	19.75	
	42.11	40.48	55.36	
2 years < 7 year	36	40	15	162
	9.65	10.72	4.02	43.43
	22.22	24.69	9.26	
	47.37	47.62	26.79	
7 years or more	8	10	10	54
	2.14	2.68	2.68	14.48
	14.81	18.52	18.52	
	10.53	11.90	17.86	
Total	76	84	56	373
	20.38	22.52	15.01	100.00

Appendix F: Reporting FIM Errors Response by Demographic Data

TABLE OF GRADE BY ERROR REPORTING

GRADE(grade of technicians)

ERRORRPT

Frequency Percent Row Pct Col Pct	Tell Supervisor	AFTO 22	Ignore	No Errors Seen	Other	Total
E1/E2/E3	29 7.77 35.37 24.79	8 2.14 9.76 7.69	10 2.68 12.20 25.64	28 7.51 34.15 34.57	7 1.88 8.54 21.88	82 21.98
E4	41 10.99 38.32 35.04	22 5.90 20.56 21.15	11 2.95 10.28 28.21	27 7.24 25.23 33.33	6 1.61 5.61 18.75	107 28.69
E5	38 10.19 31.93 32.48	40 10.72 33.61 38.46	13 3.49 10.92 33.33	17 4.56 14.29 20.99	11 2.95 9.24 34.38	119 31.90
E6	8 2.14 16.67 6.84	26 6.97 54.17 25.00	3 0.80 6.25 7.69	7 1.88 14.58 8.64	4 1.07 8.33 12.50	48 12.87
E7/E8	1 0.27 5.88 0.85	8 2.14 47.06 7.69	2 0.54 11.76 5.13	2 0.54 11.76 2.47	4 1.07 23.53 12.50	17 4.56
Total	117 31.37	104 27.88	39 10.46	81 21.72	32 8.58	373 100.00

TABLE OF AFSC BY ERROR REPORTING

AFSC(afsc of technicians)

ERRORRPT

Frequency Percent Row Pct Col Pct	Tell Supervisor	AFTO 22	Ignore	No Errors Seen	Other	Total
452X4B	41 10.99 27.15 35.04	36 9.65 23.84 34.62	18 4.83 11.92 46.15	36 9.65 23.84 44.44	20 5.36 13.25 62.50	151 40.48
452X2B	8 2.14 33.33 6.84	7 1.88 29.17 6.73	3 0.80 12.50 7.69	5 1.34 20.83 6.17	1 0.27 4.17 3.13	24 6.43
462X0	46 12.33 42.20 39.32	30 8.04 27.52 28.85	6 1.61 5.50 15.38	22 5.90 20.18 27.16	5 1.34 4.59 15.63	109 29.22
452X5	6 1.61 19.35 5.13	15 4.02 48.39 14.42	2 0.54 6.45 5.13	7 1.88 22.58 8.64	1 0.27 3.23 3.13	31 8.31
452X2C	7 1.88 38.89 5.98	4 1.07 22.22 3.85	1 0.27 5.56 2.56	6 1.61 33.33 7.41	0 0.00 0.00 0.00	18 4.83
452X2A	6 1.61 37.50 5.13	2 0.54 12.50 1.92	4 1.07 25.00 10.26	2 0.54 12.50 2.47	2 0.54 12.50 6.25	16 4.29
45272	3 0.80 12.50 2.56	10 2.68 41.67 9.62	5 1.34 20.83 12.82	3 0.80 12.50 3.70	3 0.80 12.50 9.38	24 6.43
Total	117 31.37	104 27.88	39 10.46	81 21.72	32 8.58	373 100.00

TABLE OF SKILL BY ERROR REPORTING

SKILL(skill level of technicians)

ERRORRPT

Frequency / Percent / Row Pct / Col Pct	Tell Supervisor	AFTO 22	Ignore	No Errors Seen	Other	Total
3	14	4	4	19	7	48
	3.75	1.07	1.07	5.09	1.88	12.87
	29.17	8.33	8.33	39.58	14.58	
	11.97	3.85	10.26	23.46	21.88	
5	64	29	19	38	8	158
	17.16	7.77	5.09	10.19	2.14	42.36
	40.51	18.35	12.03	24.05	5.06	
	54.70	27.88	48.72	46.91	25.00	
7 and 9	39	71	16	24	17	167
	10.46	19.03	4.29	6.43	4.56	44.77
	23.35	42.51	9.58	14.37	10.18	
	33.33	68.27	41.03	29.63	53.13	
Total	117	104	39	81	32	373
	31.37	27.88	10.46	21.72	8.58	100.00

TABLE OF BASE BY ERROR REPORTING

BASE(base of technicians)

ERRORRPT

Frequency / Percent / Row Pct / Col Pct	Tell Supervisor	AFTO 22	Ignore	No Errors Seen	Other	Total
Homestead	17	6	14	17	8	62
	4.55	1.60	3.74	4.55	2.14	16.58
	27.42	9.68	22.58	27.42	12.90	
	14.41	5.77	35.90	20.99	25.00	
Shaw	20	20	10	14	5	69
	5.35	5.35	2.67	3.74	1.34	18.45
	28.99	28.99	14.49	20.29	7.25	
	16.95	19.23	25.64	17.28	15.63	
MacDill	33	20	3	15	4	75
	8.82	5.35	0.80	4.01	1.07	20.05
	44.00	26.67	4.00	20.00	5.33	
	27.97	19.23	7.69	18.52	12.50	
Luke	21	25	3	13	8	70
	5.61	6.68	0.80	3.48	2.14	18.72
	30.00	35.71	4.29	18.57	11.43	
	17.80	24.04	7.69	16.05	25.00	
Moody	16	15	4	13	1	49
	4.28	4.01	1.07	3.48	0.27	13.10
	32.65	30.61	8.16	26.53	2.04	
	13.56	14.42	10.26	16.05	3.13	
Hill	10	18	5	9	6	48
	2.67	4.81	1.34	2.41	1.60	12.83
	20.83	37.50	10.42	18.75	12.50	
	8.47	17.31	12.82	11.11	18.75	
Total	118	104	39	81	32	374
	31.55	27.81	10.43	21.66	8.56	100.00

TABLE OF MXEXP BY ERROR REPORTING

MXEXP(Mainteance Experience of Technicians)

ERRORRPT

Frequency / Percent / Row Pct / Col Pct	Tell Supervisor	AFTO 22	Ignore	No Errors Seen	Other	Total
less than 2 year	20	7	6	23	9	65
	5.35	1.87	1.60	6.15	2.41	17.38
	30.77	10.77	9.23	35.38	13.85	
	16.95	6.73	15.38	28.40	28.13	
2 years < 7 year	52	0 23	16	32	7	130
	13.90	6.15	4.28	8.56	1.87	34.76
	40.00	17.69	12.31	24.62	5.38	
	44.07	22.12	41.03	39.51	21.88	
7 years or more	46	74	17	26	16	179
	12.30	19.79	4.55	6.95	4.28	47.86
	25.70	41.34	9.50	14.53	8.94	
	38.98	71.15	43.59	32.10	50.00	
Total .	118	104	39	81	32	374
	31.55	27.81	10.43	21.66	8.56	100.00

TABLE OF F16EXP BY ERROR REPORTING

F16EXP(F-16 Experience of Technicians)

ERRORRPT

Frequency Percent Row Pct Col Pct	Tell Supervisor	AFTO 22	Ignore	No Errors Seen	Other	Total
less than 2 year	29 7.75 26.13 24.58	16 4.28 14.41 15.38	14 3.74 12.61 35.90	39 10.43 35.14 48.15	13 3.48 11.71 40.63	111 29.68
2 years < 7 year	72 19.25 37.31 61.02	55 14.71 28.50 52.88	17 4.55 8.81 43.59	36 9.63 18.65 44.44	13 3.48 6.74 40.63	193 51.60
7 years or more	17 4.55 24.29 14.41	33 8.82 47.14 31.73	8 2.14 11.43 20.51	6 1.60 8.57 7.41	6 1.60 8.57 18.75	70 18.72
Total	118 31.55	104 27.81	39 10.43	81 21.66	32 8.56	374 100.00

TABLE OF FIMEXP BY ERROR REPORTING

FIMEXP(FIM Experience by Technicians)

ERRORRPT

Frequency / Percent / Row Pct / Col Pct	Tell Supervisor	AFTO 22	Ignore	No Errors Seen	Other	Total
less than 2 years	47 12.57 29.75 39.83	26 6.95 16.46 25.00	17 4.55 10.76 43.59	54 14.44 34.18 66.67	14 3.74 8.86 43.75	158 42.25
2 years < 7 year	61 16.31 37.65 51.69	50 13.37 30.86 48.08	14 3.74 8.64 35.90	23 6.15 14.20 28.40	14 3.74 8.64 43.75	162 43.32
7 years or more	10 2.67 18.52 8.47	28 7.49 51.85 26.92	8 2.14 14.81 20.51	4 1.07 7.41 4.94	4 1.07 7.41 12.50	54 14.44
Total	118 31.55	104 27.81	39 10.43	81 21.66	32 8.56	374 100.00

Appendix G: Improving the FIM Response by Demographic Data

TABLE OF GRADE BY IMPROVE

GRADE(grade of technicians) / IMPROVE

Frequency / Percent / Row Pct / Col Pct	Improve Illustra	More Step by Ste	Improve F.T. Acc	Improve Isolatio
E1/E2/E3	8 2.14 9.64 29.63	8 2.14 9.64 26.67	20 5.36 24.10 18.69	12 3.22 14.46 13.33
E4	7 1.88 6.54 25.93	9 2.41 8.41 30.00	30 8.04 28.04 28.04	26 6.97 24.30 28.89
E5	8 2.14 6.78 29.63	9 2.41 7.63 30.00	38 10.19 32.20 35.51	32 8.58 27.12 35.56
E6	4 1.07 8.33 14.81	2 0.54 4.17 6.67	15 4.02 31.25 14.02	16 4.29 33.33 17.78
E7/E8	0 0.00 0.00 0.00	2 0.54 11.76 6.67	4 1.07 23.53 3.74	4 1.07 23.53 4.44
Total	27 7.24	30 8.04	107 28.69	90 24.13

(Continued)

TABLE OF GRADE BY IMPROVE

GRADE(grade of technicians)

Frequency / Percent / Row Pct / Col Pct	IMPROVE: Improve Indexes	Improve Training	Other	Total
E1/E2/E3	4 1.07 4.82 20.00	26 6.97 31.33 36.11	5 1.34 6.02 18.52	83 22.25
E4	6 1.61 5.61 30.00	18 4.83 16.82 25.00	11 2.95 10.28 40.74	107 28.69
E5	5 1.34 4.24 25.00	18 4.83 15.25 25.00	8 2.14 6.78 29.63	118 31.64
E6	1 0.27 2.08 5.00	8 2.14 16.67 11.11	2 0.54 4.17 7.41	48 12.87
E7/E8	4 1.07 23.53 20.00	2 0.54 11.76 2.78	1 0.27 5.88 3.70	17 4.56
Total	20 5.36	72 19.30	27 7.24	373 100.00

TABLE OF AFSC BY IMPROVE

AFSC(afsc of technicians) IMPROVE

Frequency / Percent / Row Pct / Col Pct

AFSC	Improve Illustra	More Step by Ste	Improve F.T. 'Acc	Improve Isolatio
452X4B	16 4.29 10.60 59.26	15 4.02 9.93 50.00	27 7.24 17.88 25.23	28 7.51 18.54 31.11
452X2B	0 0.00 0.00 0.00	0 0.00 0.00 0.00	9 2.41 36.00 8.41	8 2.14 32.00 8.89
462X0	6 1.61 5.56 22.22	8 2.14 7.41 26.67	29 7.77 26.85 27.10	30 8.04 27.78 33.33
452X5	2 0.54 6.45 7.41	4 1.07 12.90 13.33	16 4.29 51.61 14.95	6 1.61 19.35 6.67
452X2C	2 0.54 11.11 7.41	2 0.54 11.11 6.67	8 2.14 44.44 7.48	4 1.07 22.22 4.44
452X2A	0 0.00 0.00 0.00	1 0.27 6.25 3.33	8 2.14 50.00 7.48	2 0.54 12.50 2.22
45272	1 0.27 4.17 3.70	0 0.00 0.00 0.00	10 2.68 41.67 9.35	12 3.22 50.00 13.33
Total	27 7.24	30 8.04	107 28.69	90 24.13

(Continued)

TABLE OF AFSC BY IMPROVE

AFSC (AFSC of technicians)

IMPROVE

Frequency / Percent / Row Pct / Col Pct	Improve Indexes	Improve Training	Other	Total
452X4B	12	39	14	151
	3.22	10.46	3.75	40.48
	7.95	25.83	9.27	
	60.00	54.17	51.85	
452X2B	0	4	4	25
	0.00	1.07	1.07	6.70
	0.00	16.00	16.00	
	0.00	5.56	14.81	
462X0	6	21	8	108
	1.61	5.63	2.14	28.95
	5.56	19.44	7.41	
	30.00	29.17	29.63	
452X5	0	3	0	31
	0.00	0.80	0.00	8.31
	0.00	9.68	0.00	
	0.00	4.17	0.00	
452X2C	0	1	1	18
	0.00	0.27	0.27	4.83
	0.00	5.56	5.56	
	0.00	1.39	3.70	
452X2A	1	4	0	16
	0.27	1.07	0.00	4.29
	6.25	25.00	0.00	
	5.00	5.56	0.00	
45272	1	0	0	24
	0.27	0.00	0.00	6.43
	4.17	0.00	0.00	
	5.00	0.00	0.00	
Total	20	72	27	373
	5.36	19.30	7.24	100.00

TABLE OF SKILL BY IMPROVE

SKILL(skill level of technicians)

IMPROVE

Frequency / Percent / Row Pct / Col Pct	Improve Illustra	More Site p by Ste	Improve F.T. Acc	Improve Isolatio
3	5 1.34 10.20 18.52	4 1.07 8.16 13.33	10 2.68 20.41 9.35	5 1.34 10.20 5.56
5	11 2.95 6.96 40.74	13 3.49 8.23 43.33	43 11.53 27.22 40.19	39 10.46 24.68 43.33
7 and 9	11 2.95 6.63 40.74	13 3.49 7.83 43.33	54 14.48 32.53 50.47	46 12.33 27.71 51.11
Total	27 7.24	30 8.04	107 28.69	90 24.13

(Continued)

TABLE OF SKILL BY IMPROVE

SKILL(skill level of technicians)

IMPROVE

Frequency / Percent / Row Pct / Col Pct	Improve Indexes	Improve Training	Other	Total
3	4 1.07 8.16 20.00	16 4.29 32.65 22.22	5 1.34 10.20 18.52	49 13.14
5	8 2.14 5.06 40.00	33 8.85 20.89 45.83	11 2.95 6.96 40.74	158 42.36
7 and 9	8 2.14 4.82 40.00	23 6.17 13.86 31.94	11 2.95 6.63 40.74	166 44.50
Total	20 5.36	72 19.30	27 7.24	373 100.00

TABLE OF BASE BY IMPROVE

BASE(base of technicians) IMPROVE

Frequency / Percent / Row Pct / Col Pct	Improve Illustra	More Step by Ste	Improve F.T. Acc	Improve Isolatio
Homestead	7	2	18	13
	1.87	0.53	4.81	3.48
	11.29	3.23	29.03	20.97
	25.93	6.67	16.67	14.44
Shaw	2	7	26	18
	0.53	1.87	6.95	4.81
	2.90	10.14	37.68	26.09
	7.41	23.33	24.07	20.00
MacDill	5	9	16	15
	1.34	2.41	4.28	4.01
	6.58	11.84	21.05	19.74
	18.52	30.00	14.81	16.67
Luke	3	8	21	21
	0.80	2.14	5.61	5.61
	4.29	11.43	30.00	30.00
	11.11	26.67	19.44	23.33
Moody	4	3	17	14
	1.07	0.80	4.55	3.74
	8.16	6.12	34.69	28.57
	14.81	10.00	15.74	15.56
Hill	6	1	9	9
	1.60	0.27	2.41	2.41
	12.77	2.13	19.15	19.15
	22.22	3.33	8.33	10.00
Total	27	30	108	90
	7.22	8.02	28.88	24.06

(Continued)

TABLE OF BASE BY IMPROVE

BASE(base of technicians) — IMPROVE

Frequency / Percent / Row Pct / Col Pct	Improve Indexes	Improve Training	Other	Total
Homestead	2 0.53 3.23 10.00	15 4.01 24.19 20.83	5 1.34 8.06 18.52	62 16.58
Shaw	3 0.80 4.35 15.00	11 2.94 15.94 15.28	2 0.53 2.90 7.41	69 18.45
MacDill	6 1.60 7.89 30.00	18 4.81 23.68 25.00	7 1.87 9.21 25.93	76 20.32
Luke	4 1.07 5.71 20.00	9 2.41 12.86 12.50	4 1.07 5.71 14.81	70 18.72
Moody	3 0.80 6.12 15.00	7 1.87 14.29 9.72	1 0.27 2.04 3.70	49 13.10
Hill	2 0.53 4.26 10.00	12 3.21 25.53 16.67	8 2.14 17.02 29.63	47 12.57
Total	20 5.35	72 19.25	27 7.22	374 100.00

TABLE OF MXEXP BY IMPROVE

MXEXP(Mainteance Experience of Technicians)

IMPROVE

Frequency / Percent / Row Pct / Col Pct	Improve Illustra	More Step by Ste	Improve F.T. Acc	Improve Isolatio
less than 2 yea	5 1.34 7.58 18.52	6 1.60 9.09 20.00	14 3.74 21.21 12.96	9 2.41 13.64 10.00
2 years < 7 year	11 2.94 8.53 40.74	10 2.67 7.75 33.33	38 10.16 29.46 35.19	31 8.29 24.03 34.44
7 years or more	11 2.94 6.15 40.74	14 3.74 7.82 46.67	56 14.97 31.28 51.85	50 13.37 27.93 55.56
Total	27 7.22	30 8.02	108 28.88	90 24.06

(Continued)

TABLE OF MXEXP BY IMPROVE

MXEXP(Mainteance Experience of Technicians)

IMPROVE

Frequency / Percent / Row Pct / Col Pct	Improve Indexes	Improve Training	Other	Total
less than 2 year	5 1.34 7.58 25.00	22 5.88 33.33 30.56	5 1.34 7.58 18.52	66 17.65
2 years < 7 year	6 1.60 4.65 30.00	22 5.88 17.05 30.56	11 2.94 8.53 40.74	129 34.49
7 years or more	9 2.41 5.03 45.00	28 7.49 15.64 38.89	11 2.94 6.15 40.74	179 47.86
Total	20 5.35	72 19.25	27 7.22	374 100.00

TABLE OF F16EXP BY IMPROVE

F16EXP(F-16 Experience of Technicians)

Frequency / Percent / Row Pct / Col Pct	IMPROVE: Improve Illustra	More Ste p by Ste	Improve F.T. Acc	Improve Isolatio
less than 2 year	11	11	25	17
	2.94	2.94	6.68	4.55
	9.82	9.82	22.32	15.18
	40.74	36.67	23.15	18.89
2 years < 7 year	13	14	50	56
	3.48	3.74	13.37	14.97
	6.77	7.29	26.04	29.17
	48.15	46.67	46.30	62.22
7 years or more	3	5	33	17
	0.80	1.34	8.82	4.55
	4.29	7.14	47.14	24.29
	11.11	16.67	30.56	18.89
Total	27	30	108	90
	7.22	8.02	28.88	24.06

(Continued)

TABLE OF F16EXP BY IMPROVE

F16EXP(F-16 Experience of Technicians) IMPROVE

Frequency / Percent / Row Pct / Col Pct	Improve Indexes	Improve Training	Other	Total
less than 2 year	8 2.14 7.14 40.00	31 8.29 27.68 43.06	9 2.41 8.04 33.33	112 29.95
2 years < 7 year	7 1.87 3.65 35.00	36 9.63 18.75 50.00	16 4.28 8.33 59.26	192 51.34
7 years or more	5 1.34 7.14 25.00	5 1.34 7.14 6.94	2 0.53 2.86 7.41	70 18.72
Total	20 5.35	72 19.25	27 7.22	374 100.00

TABLE OF FIMEXP BY IMPROVE

FIMEXP(FIM Experience by Technicians)

Frequency Percent Row Pct Col Pct	IMPROVE Improve Illustra	More Step by Ste	Improve F.T. Acc	Improve Isolatio
less than 2 year	17 4.55 10.69 62.96	15 4.01 9.43 50.00	27 7.22 16.98 25.00	31 8.29 19.50 34.44
2 years < 7 year	9 2.41 5.59 33.33	11 2.94 6.83 36.67	52 13.90 32.30 48.15	45 12.03 27.95 50.00
7 years or more	1 0.27 1.85 3.70	4 1.07 7.41 13.33	29 7.75 53.70 26.85	14 3.74 25.93 15.56
Total	27 7.22	30 8.02	108 28.88	90 24.06

(Continued)

TABLE OF FIMEXP BY IMPROVE

FIMEXP(FIM Experience by Technicians)

IMPROVE

Frequency / Percent / Row Pct / Col Pct	Improve Indexes	Improve Training	Other	Total
less than 2 year	10	46	13	159
	2.67	12.30	3.48	42.51
	6.29	28.93	8.18	
	50.00	63.89	48.15	
2 years < 7 year	6	25	13	161
	1.60	6.68	3.48	43.05
	3.73	15.53	8.07	
	30.00	34.72	48.15	
7 years or more	4	1	1	54
	1.07	0.27	0.27	14.44
	7.41	1.85	1.85	
	20.00	1.39	3.70	
Total	20	72	27	374
	5.35	19.25	7.22	100.00

Appendix H: Normality Test Information

Normality Test for F-16 FIM Survey Data

Univariate Procedure

Variable=NORMAL

Moments

N	375	Sum Wgts	375
Mean	107.6693	Sum	40376
Std Dev	13.65493	Variance	186.4572
Skewness	-0.30748	Kurtosis	0.260244
USS	4416992	CSS	69735
CV	12.68229	Std Mean	0.705138
T:Mean=0	152.6926	Prob>¦T¦	0.0001
Num ^= 0	375	Num > 0	375
M(Sign)	187.5	Prob>¦M¦	0.0001
Sgn Rank	35250	Prob>¦S¦	0.0001
W:Normal	0.981428	Prob<W	0.2298

Normality Test for F-16 FIM Survey Data

Variable=NORMAL

```
                Histogram                    #
142.5+*                                      1
     .****                                   7
     .*******                               14
     .**********                            20
     .***************                       30
     .***********************               46
     .****************************          55
     .*********************************     65
102.5+**********************                44
     .******************                    35
     .***********                           21
     .*********                             18
     .****                                   7
     .****                                   7
     .*                                      2
     .*                                      2
 62.5+*                                      1
     .----+----+----+----+----+----+---
```

<u>Responses</u>

* may represent up to 2 counts

```
                 Normal Probability Plot
142.5+                                                 +*
     |                                             **** *
     |                                         ****+
     |                                     ****+
     |                                  ****
     |                              *****
     |                          *****
     |                      *****
102.5+                  ****++
     |               ****+
     |            ****
     |         ****
     |     ++**
     |  +****
     |++**
     |*
 62.5+*
      +----+----+----+----+----+----+----+----+----+----+
          -2        -1         0        +1        +2
```

Appendix I: ANOVA and Scheffe Means Test Results for Research Hypothesis 2.1

General Linear Models Procedure

Class Level Information

Class	Levels	Values
SKILL	3	3, 5, 7/9

Number of observations in data set = 375

GLM for skill level and fimuse

General Linear Models Procedure

Dependent Variable: FIMUSE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	1899.6529428	633.2176476	504.03	0.0001
Error	372	467.3470572	1.2563093		
Uncorrected Total	375	2367.0000000			

R-Square	C.V.	Root MSE	FIMUSE Mean
0.009724	49.85997	1.1208520	2.2480000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	895.0640000	1895.0640000	1508.44	0.0001
SKILL	2	4.5889428	2.2944714	1.83	0.1624

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	1313.9446781	1313.9446781	1045.88	0.0001
SKILL	2	4.5889428	2.2944714	1.83	0.1624

GLM for skill level and fimuse

General Linear Models Procedure

Scheffe's test for variable: FIMUSE

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than Tukey's for all pairwise comparisons.

Alpha= 0.05 Confidence= 0.95 df= 372 MSE= 1.256309
Critical Value of F= 3.01999

Comparisons significant at the 0.05 level are indicated by '***'.

Skill Level Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit
7/9 - 5	-0.2247	0.0805	0.3858
7/9 - 3	-0.0995	0.3478	0.7950
5 - 7/9	-0.3858	-0.0805	0.2247
5 - 3	-0.1832	0.2672	0.7177
3 - 7/9	-0.7950	-0.3478	0.0995
3 - 5	-0.7177	-0.2672	0.1832

GLM for AFSC and fimuse

General Linear Models Procedure

Class Level Information

Class	Levels	Values
AFSC	7	45272 452X5 452X2A 452X2B 452X2C 452X4B 462X0

Number of observations in data set = 375

GLM for afsc and fimuse

General Linear Models Procedure

Dependent Variable: FIMUSE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	1924.7301731	274.9614533	228.79	0.0001
Error	368	442.2698269	1.2018202		
Uncorrected Total	375	2367.0000000			

R-Square	C.V.	Root MSE	FIMUSE Mean
0.062861	48.76671	1.0962756	2.2480000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	1895.0640000	1895.0640000	1576.83	0.0001
AFSC	6	29.6661731	4.9443622	4.11	0.0005

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	935.77023643	935.77023643	778.63	0.0001
AFSC	6	29.66617313	4.94436219	4.11	0.0005

GLM for AFSC and fimuse

General Linear Models Procedure

Scheffe's test for variable: FIMUSE

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than Tukey's for all pairwise comparisons.

Alpha= 0.05 Confidence= 0.95 df= 368 MSE= 1.20182
Critical Value of F= 2.12323

Comparisons significant at the 0.05 level are indicated by '***'.

AFSC Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit
462X0 - 452X2A	-1.0288	0.0182	1.0651
462X0 - 452X5	-0.7291	0.0666	0.8622
462X0 - 452X2B	-0.7488	0.1182	0.9851
462X0 - 452X4B	-0.1048	0.3857	0.8762
462X0 - 45272	-0.0300	0.8515	1.7331
462X0 - 452X2C	-0.0322	0.9626	1.9575
452X2A - 462X0	-1.0651	-0.0182	1.0288
452X2A - 452X5	-1.1561	0.0484	1.2529
452X2A - 452X2B	-1.1527	0.1000	1.3527
452X2A - 452X4B	-0.6612	0.3675	1.3963
452X2A - 45272	-0.4295	0.8333	2.0962
452X2A - 452X2C	-0.4000	0.9444	2.2889
452X5 - 462X0	-0.8622	-0.0666	0.7291
452X5 - 452X2A	-1.2529	-0.0484	1.1561
452X5 - 452X2B	-1.0002	0.0516	1.1034
452X5 - 452X4B	-0.4524	0.3192	1.0907
452X5 - 45272	-0.2789	0.7849	1.8488
452X5 - 452X2C	-0.2635	0.8961	2.0556
452X2B - 462X0	-0.9851	-0.1182	0.7488
452X2B - 452X2A	-1.3527	-0.1000	1.1527
452X2B - 452X5	-1.1034	-0.0516	1.0002
452X2B - 452X4B	-0.5773	0.2675	1.1124
452X2B - 45272	-0.3849	0.7333	1.8515
452X2B - 452X2C	-0.3651	0.8444	2.0540

Scheffe's test for variable: FIMUSE Cont'd

AFSC Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit
452X4B - 462X0	-0.8762	-0.3857	0.1048
452X4B - 452X2A	-1.3963	-0.3675	0.6612
452X4B - 452X5	-1.0907	-0.3192	0.4524
452X4B - 452X2B	-1.1124	-0.2675	0.5773
452X4B - 45272	-0.3941	0.4658	1.3256
452X4B - 452X2C	-0.3988	0.5769	1.5526
45272 - 462X0	-1.7331	-0.8515	0.0300
45272 - 452X2A	-2.0962	-0.8333	0.4295
45272 - 452X5	-1.8488	-0.7849	0.2789
45272 - 452X2B	-1.8515	-0.7333	0.3849
45272 - 452X4B	-1.3256	-0.4658	0.3941
45272 - 452X2C	-1.1089	0.1111	1.3312
452X2C - 462X0	-1.9575	-0.9626	0.0322
452X2C - 452X2A	-2.2889	-0.9444	0.4000
452X2C - 452X5	-2.0556	-0.8961	0.2635
452X2C - 452X2B	-2.0540	-0.8444	0.3651
452X2C - 452X4B	-1.5526	-0.5769	0.3988
452X2C - 45272	-1.3312	-0.1111	1.1089

GLM for grade and fimuse

General Linear Models Procedure

Class Level Information

Class	Levels	Values
GRADE	5	E1/E2/E3,E4,E5,E6,E7/E8

Number of observations in data set = 375

GLM for grade and fimuse

General Linear Models Procedure

Dependent Variable: FIMUSE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	1903.4169425	380.6833885	303.84	0.0001
Error	370	463.5830575	1.2529272		
Uncorrected Total	375	2367.0000000			

R-Square	C.V.	Root MSE	FIMUSE Mean
0.017699	49.79281	1.1193423	2.2480000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	1895.0640000	1895.0640000	1512.51	0.0001
GRADE	4	8.3529425	2.0882356	1.67	0.1571

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	1256.4916636	1256.4916636	1002.84	0.0001
GRADE	4	8.3529425	2.0882356	1.67	0.1571

GLM for grade and fimuse

General Linear Models Procedure

Scheffe's test for variable: FIMUSE

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than Tukey's for all pairwise comparisons.

Alpha= 0.05 Confidence= 0.95 df= 370 MSE= 1.252927
Critical Value of F= 2.39607

Comparisons significant at the 0.05 level are indicated by '***'.

Grade Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit
E7/E8 - E6	-0.7185	0.2569	1.2323
E7/E8 - E4	-0.4793	0.4255	1.3303
E7/E8 - E5	-0.3775	0.5210	1.4195
E7/E8 - E1/E2/E3	-0.3010	0.6215	1.5441
E6 - E7/E8	-1.2323	-0.2569	0.7185
E6 - E4	-0.4291	0.1686	0.7663
E6 - E5	-0.3241	0.2641	0.8523
E6 - E1/E2/E3	-0.2597	0.3646	0.9889
E4 - E7/E8	-1.3303	-0.4255	0.4793
E4 - E6	-0.7663	-0.1686	0.4291
E4 - E5	-0.3662	0.0955	0.5572
E4 - E1/E2/E3	-0.3108	0.1960	0.7029
E5 - E7/E8	-1.4195	-0.5210	0.3775
E5 - E6	-0.8523	-0.2641	0.3241
E5 - E4	-0.5572	-0.0955	0.3662
E5 - E1/E2/E3	-0.3950	0.1005	0.5961
E1/E2/E3 - E7/E8	-1.5441	-0.6215	0.3010
E1/E2/E3 - E6	-0.9889	-0.3646	0.2597
E1/E2/E3 - E4	-0.7029	-0.1960	0.3108
E1/E2/E3 - E5	-0.5961	-0.1005	0.3950

GLM for base of assignment and fimuse

General Linear Models Procedure

Class Level Information

Class	Levels	Values
BASE	6	Hill, Homestead, Luke, MacDill, Moody, Shaw

Number of observations in data set = 375

GLM for base of assignment and fimuse

General Linear Models Procedure

Dependent Variable: FIMUSE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	1912.0458745	318.6743124	258.47	0.0001
Error	369	454.9541255	1.2329380		
Uncorrected Total	375	2367.0000000			

R-Square	C.V.	Root MSE	FIMUSE Mean
0.035983	49.39401	1.1103774	2.2480000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	1895.0640000	1895.0640000	1537.03	0.0001
EDUC	5	16.9818745	3.3963749	2.75	0.0185

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	1841.2459147	1841.2459147	1493.38	0.0001
EDUC	5	16.9818745	3.3963749	2.75	0.0185

high school +

GLM for base of assignment and fimuse

General Linear Models Procedure

Scheffe's test for variable: FIMUSE

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than Tukey's for all pairwise comparisons.

Alpha= 0.05 Confidence= 0.95 df= 369 MSE= 1.232938
Critical Value of F= 2.23845

Comparisons significant at the 0.05 level are indicated by '***'.

Base Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit
Moody - Luke	-0.5858	0.1061	0.7980
Moody - MacDill	-0.3651	0.3155	0.9961
Moody - Shaw	-0.1746	0.5194	1.2134
Moody - Hill	-0.2251	0.5293	1.2837
Moody - Homestead	-0.1316	0.5760	1.2835
Luke - Moody	-0.7980	-0.1061	0.5858
Luke - MacDill	-0.4060	0.2094	0.8248
Luke - Shaw	-0.2169	0.4133	1.0434
Luke - Hill	-0.2729	0.4232	1.1194
Luke - Homestead	-0.1753	0.4698	1.1150
MacDill - Moody	-0.9961	-0.3155	0.3651
MacDill - Luke	-0.8248	-0.2094	0.4060
MacDill - Shaw	-0.4139	0.2039	0.8216
MacDill - Hill	-0.4711	0.2138	0.8987
MacDill - Homestead	-0.3725	0.2604	0.8934
Shaw - Moody	-1.2134	-0.5194	0.1746
Shaw - Luke	-1.0434	-0.4133	0.2169
Shaw - MacDill	-0.8216	-0.2039	0.4139
Shaw - Hill	-0.6882	0.0100	0.7082
Shaw - Homestead	-0.5907	0.0566	0.7039

Scheffe's test for variable: FIMUSE Cont'd

Hill - Moody	-1.2837	-0.5293	0.2251
Hill - Luke	-1.1194	-0.4232	0.2729
Hill - MacDill	-0.8987	-0.2138	0.4711
Hill - Shaw	-0.7082	-0.0100	0.6882
Hill - Homestead	-0.6651	0.0466	0.7583
Homestead - Moody	-1.2835	-0.5760	0.1316
Homestead - Luke	-1.1150	-0.4698	0.1753
Homestead - MacDill	-0.8934	-0.2604	0.3725
Homestead - Shaw	-0.7039	-0.0566	0.5907
Homestead - Hill	-0.7583	-0.0466	0.6651

GLM for education level and fimuse

General Linear Models Procedure

Class Level Information

Class	Levels	Values
EDUC	3	AssocDegree, high school, high school +

Number of observations in data set = 375

GLM for education level and fimuse

General Linear Models Procedure

Dependent Variable: FIMUSE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	1895.5506908	631.8502303	498.57	0.0001
Error	372	471.4493092	1.2673369		
Uncorrected Total	375	2367.0000000			

R-Square	C.V.	Root MSE	FIMUSE Mean
0.001031	50.07832	1.1257606	2.2480000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	1895.0640000	1895.0640000	1495.31	0.0001
EDUC	2	0.4866908	0.2433454	0.19	0.8254

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	1007.6943146	1007.6943146	795.13	0.0001
EDUC	2	0.4866908	0.2433454	0.19	0.8254

GLM for education level and fimuse

General Linear Models Procedure

Scheffe's test for variable: FIMUSE

NOTE: This test controls the type I experimentwise error rate
but generally has a higher type II error rate than
Tukey's for all pairwise comparisons.

Alpha= 0.05 Confidence= 0.95 df= 372 MSE= 1.267337
Critical Value of F= 3.01999

Comparisons significant at the 0.05 level are indicated by '***'.

NOTE: AD: Associate Degree or higher;
HS +: High School +;
HS: High School

Education Level Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit
AD - HS +	-0.38610	0.12517	0.63645
AD - HS	-0.43843	0.13193	0.70229
HS + - AD	-0.63645	-0.12517	0.38610
HS + - HS	-0.34366	0.00675	0.35717
HS - AD	-0.70229	-0.13193	0.43843
HS - HS +	-0.35717	-0.00675	0.34366

GLM for maintenance experience and fimuse

General Linear Models Procedure

Class Level Information

Class	Levels	Values
MXEXP	4	+ 12 years, 2 years < 7 years, 7 years < 12 years, < 2 years

Number of observations in data set = 375

GLM for maintenance experience and fimuse

General Linear Models Procedure

Dependent Variable: FIMUSE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	1902.2449147	475.5612287	379.63	0.0001
Error	371	464.7550853	1.2527091		
Uncorrected Total	375	2367.0000000			

R-Square	C.V.	Root MSE	FIMUSE Mean
0.015216	49.78847	1.1192449	2.2480000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	1895.0640000	1895.0640000	1512.77	0.0001
MXEXP	3	7.1809147	2.3936382	1.91	0.1274

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	1732.4284191	1732.4284191	1382.95	0.0001
MXEXP	3	7.1809147	2.3936382	1.91	0.1274

GLM for maintenance experience and fimuse

General Linear Models Procedure

Scheffe's test for variable: FIMUSE

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than Tukey's for all pairwise comparisons.

Alpha= 0.05 Confidence= 0.95 df= 371 MSE= 1.252709
Critical Value of F= 2.62897

Comparisons significant at the 0.05 level are indicated by '***'.

NOTE: 2 years < 7 years: 2 < 7;
7 years < 12: 7 < 12;
12 years: 12

Maintenance Experience Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit
+ 12 - 2 < 7	-0.2852	0.1923	0.6698
+ 12 - 7 < 12	-0.1366	0.3520	0.8405
+ 12 - < 2	-0.1479	0.4014	0.9507
2 < 7 - + 12	-0.6698	-0.1923	0.2852
2 < 7 - 7 < 12	-0.2437	0.1596	0.5630
2 < 7 - < 2	-0.2660	0.2091	0.6842
7 < 12 - + 12	-0.8405	-0.3520	0.1366
7 < 12 - 2 < 7	-0.5630	-0.1596	0.2437
7 < 12 - < 2	-0.4367	0.0494	0.5356
< 2 - + 12	-0.9507	-0.4014	0.1479
< 2 - 2 < 7	-0.6842	-0.2091	0.2660
< 2 - 7 < 12	-0.5356	-0.0494	0.4367

GLM for F-16 experience and fimuse

General Linear Models Procedure

Class Level Information

Class	Levels	Values
F16EXP	3	2 years < 7 years, 7 years or more, < 2 years

Number of observations in data set = 375

GLM for F-16 experience and fimuse

General Linear Models Procedure

Dependent Variable: FIMUSE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	1897.7716969	632.5905656	501.51	0.0001
Error	372	469.2283031	1.2613664		
Uncorrected Total	375	2367.0000000			

R-Square	C.V.	Root MSE	FIMUSE Mean
0.005737	49.96022	1.1231057	2.2480000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	1895.0640000	1895.0640000	1502.39	0.0001
F16EXP	2	2.7076969	1.3538484	1.07	0.3429

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	1554.3506663	1554.3506663	1232.28	0.0001
F16EXP	2	2.7076969	1.3538484	1.07	0.3429

GLM for F-16 experience and fimuse

General Linear Models Procedure

Scheffe's test for variable: FIMUSE

NOTE: This test controls the type I experimentwise error rate
but generally has a higher type II error rate than
Tukey's for all pairwise comparisons.

Alpha= 0.05 Confidence= 0.95 df= 372 MSE= 1.261366
Critical Value of F= 3.01999

Comparisons significant at the 0.05 level are indicated by '***'.

NOTE: 2 years < 7 years: 2 < 7;
7 years or more: 7+;
< 2 years: < 2;

F-16 Experience Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit
2 < 7 - < 2	-0.3093	0.0186	0.3464
2 < 7 - 7 +	-0.1612	0.2239	0.6090
< 2 - 2 < 7	-0.3464	-0.0186	0.3093
< 2 - 7 +	-0.2152	0.2054	0.6259
7 + - 2 < 7	-0.6090	-0.2239	0.1612
7 + - < 2	-0.6259	-0.2054	0.2152

GLM for FIM experience and fimuse

General Linear Models Procedure

Class Level Information

Class	Levels	Values
FIMEXP	3	2 years < 7 years, 7 years or more, < 2 years

Number of observations in data set = 375

GLM for FIM experience and fimuse

General Linear Models Procedure

Dependent Variable: FIMUSE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	1898.3825996	32.7941999	502.33	0.0001
Error	372	468.6174004	1.2597242		
Uncorrected Total	375	2367.0000000			

R-Square	C.V.	Root MSE	FIMUSE Mean
0.007032	49.92768	1.1223744	2.2480000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	1895.0640000	1895.0640000	1504.35	0.0001
FIMEXP	2	3.3185996	1.6592998	1.32	0.2691

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	1428.1275870	1428.1275870	1133.68	0.0001
FIMEXP	2	3.3185996	1.6592998	1.32	0.2691

GLM for FIM experience and fimuse

General Linear Models Procedure

Scheffe's test for variable: FIMUSE

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than Tukey's for all pairwise comparisons.

Alpha= 0.05 Confidence= 0.95 df= 372 MSE= 1.259724
Critical Value of F= 3.01999

Comparisons significant at the 0.05 level are indicated by '***'.

NOTE: 2 years < 7 years: 2 < 7;
7 years or more: 7+;
< 2 years: < 2;

FIM Experience Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit
2 < 7 - 2	-0.1448	0.1632	0.4711
2 < 7 - 7 +	-0.1927	0.2407	0.6742
< 2 - 2 < 7	-0.4711	-0.1632	0.1448
< 2 - 7 +	-0.3569	0.0776	0.5120
7 + - 2 < 7	-0.6742	-0.2407	0.1927
7 + - < 2	-0.5120	-0.0776	0.3569

Appendix J: ANOVA and Scheffe Means Test Results for Research Hypothesis 3.1

GLM for skill and combined use variable

General Linear Models Procedure

Class Level Information

Class	Levels	Values
SKILL	3	3 5 7 and 9

Number of observations in data set = 375

GLM for skill and combined use variable

General Linear Models Procedure

Dependent Variable: USE   Sum of FIM Usefulness Measures

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	546159.57108	182053.19036	7214.31	0.0001
Error	372	9387.42892	25.23502		
Uncorrected Total	375	555547.00000			

R-Square	C.V.	Root MSE	USE Mean
0.001452	13.16325	5.0234474	38.162667

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	546145.92267	546145.92267	21642.38	0.0001
SKILL	?	13.64842	6.82421	0.27	0.7632

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	402149.63322	402149.63322	15936.17	0.0001
SKILL	2	13.64842	6.82421	0.27	0.7632

GLM for skill and combined use variable

General Linear Models Procedure

Scheffe's test for variable: USE

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than Tukey's for all pairwise comparisons.

Alpha= 0.05 Confidence= 0.95 df= 372 MSE= 25.23502
Critical Value of F= 3.01999

Comparisons significant at the 0.05 level are indicated by '***'.

SKILL Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit
3 - 5	-1.9474	0.0713	2.0900
3 - 7/9	-1.5691	0.4354	2.4398
5 - 3	-2.0900	-0.0713	1.9474
5 - 7/9	-1.0041	0.3641	1.7323
7/9 - 3	-2.4398	-0.4354	1.5691
7/9 - 5	-1.7323	-0.3641	1.0041

GLM for afsc and combined use variable

General Linear Models Procedure

Class Level Information

Class	Levels	Values
AFSC	7	45272 452X5 452X2A 452X2B 452X2C 452X4B 462X0

Number of observations in data set = 375

GLM for afsc and combined use variable

General Linear Models Procedure

Dependent Variable: USE   Sum of FIM Usefulness Measures

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	546653.47662	78093.35380	3231.38	0.0001
Error	368	8893.52338	24.16718		
Uncorrected Total	375	555547.00000			

R-Square	C.V.	Root MSE	USE Mean
0.053989	12.88173	4.9160129	38.162667

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	546145.92267	546145.92267	22598.66	0.0001
AFSC	6	507.55395	84.59233	3.50	0.0022

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	283529.50895	283529.50895	11732.00	0.0001
AFSC	6	507.55395	84.59233	3.50	0.0022

GLM for afsc and combined use variable

General Linear Models Procedure

Scheffe's test for variable: USE

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than Tukey's for all pairwise comparisons..

Alpha= 0.05 Confidence= 0.95 df= 368 MSE= 24.16718
Critical Value of F= 2.12323

Comparisons significant at the 0.05 level are indicated by '***'.

AFSC Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
452X5 - 452X2C	-5.1870	0.0125	5.2121	
452X5 - 462X0	-3.3049	0.2630	3.8310	
452X5 - 452X4B	-2.1165	1.3433	4.8031	
452X5 - 452X2A	-3.7984	1.6028	7.0041	
452X5 - 452X2B	-2.7863	1.9303	6.6469	
452X5 - 45272	0.1030	4.8737	9.6444	***
452X2C - 452X5	-5.2121	-0.0125	5.1870	
452X2C - 462X0	-4.2108	0.2505	4.7118	
452X2C - 452X4B	-3.0445	1.3308	5.7060	
452X2C - 452X2A	-4.4385	1.5903	7.6191	
452X2C - 452X2B	-3.5062	1.9178	7.3417	
452X2C - 45272	-0.6099	4.8611	10.3322	
462X0 - 452X5	-3.8310	-0.2630	3.3049	
462X0 - 452X2C	-4.7118	-0.2505	4.2108	
462X0 - 452X4B	-1.1192	1.0803	3.2797	
462X0 - 452X2A	-3.3550	1.3398	6.0346	
462X0 - 452X2B	-2.2204	1.6673	5.5549	
462X0 - 45272	0.6575	4.6106	8.5637	***
452X4B - 452X5	-4.8031	-1.3433	2.1165	
452X4B - 452X2C	-5.7060	-1.3308	3.0445	
452X4B - 462X0	-3.2797	-1.0803	1.1192	
452X4B - 452X2A	-4.3536	0.2595	4.8727	
452X4B - 452X2B	-3.2016	0.5870	4.3757	
452X4B - 45272	-0.3254	3.5304	7.3861	

Scheffe's test for variable: USE cont'd

AFSC Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
452X2A - 452X5	-7.0041	-1.6028	3.7984	
452X2A - 452X2C	-7.6191	-1.5903	4.4385	
452X2A - 462X0	-6.0346	-1.3398	3.3550	
452X2A - 452X4B	-4.8727	-0.2595	4.3536	
452X2A - 452X2B	-5.2901	0.3275	5.9451	
452X2A - 45272	-2.3922	3.2708	8.9339	
452X2B - 452X5	-6.6469	-1.9303	2.7863	
452X2B - 452X2C	-7.3417	-1.9178	3.5062	
452X2B - 462X0	-5.5549	-1.6673	2.2204	
452X2B - 452X4B	-4.3757	-0.5870	3.2016	
452X2B - 452X2A	-5.9451	-0.3275	5.2901	
452X2B - 45272	-2.0710	2.9433	7.9576	
45272 - 452X5	-9.6444	-4.8737	-0.1030	***
45272 - 452X2C	-10.3322	-4.8611	0.6099	
45272 - 462X0	-8.5637	-4.6106	-0.6575	***
45272 - 452X4B	-7.3861	-3.5304	0.3254	
45272 - 452X2A	-8.9339	-3.2708	2.3922	
45272. - 452X2B	-7.9576	-2.9433	2.0710	

GLM for grade and combined use variable

General Linear Models Procedure

Class Level Information

Class	Levels	Values
GRADE	5	E1/E2/E3, E4, E5, E6, E7/E8

Number of observations in data set = 375

GLM for grade and combined use variable

General Linear Models Procedure

Dependent Variable: USE   Sum of FIM Usefulness Measures

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	546220.92604	109244.18521	4334.12	0.0001
Error	370	9326.07396	25.20561		
Uncorrected Total	375	555547.00000			

R-Square	C.V.	Root MSE	USE Mean
0.007978	13.15558	5.0205184	38.162667

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	546145.92267	546145.92267	21667.64	0.0001
GRADE	4	75.00337	18.75084	0.74	0.5626

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	330258.48389	330258.48389	13102.58	0.0001
GRADE	4	75.00337	18.75084	0.74	0.5626

GLM for grade and combined use variable

General Linear Models Procedure

Scheffe's test for variable: USE

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than Tukey's for all pairwise comparisons.

Alpha= 0.05 Confidence= 0.95 df= 370 MSE= 25.20561
Critical Value of F= 2.39607

Comparisons significant at the 0.05 level are indicated by '***'.

GRADE Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit
E5 - E1/E2/E3	-2.0007	0.2220	2.4448
E5 - E4	-1.6021	0.4686	2.5393
E5 - E7/E8	-2.9879	1.0420	5.0720
E5 - E6	-1.2709	1.3673	4.0056
E1/E2/E3 - E5	-2.4448	-0.2220	2.0007
E1/E2/E3 - E4	-2.0268	0.2466	2.5200
E1/E2/E3 - E7/E8	-3.3178	0.8200	4.9577
E1/E2/E3 - E6	-1.6548	1.1453	3.9454
E4 - E5	-2.5393	-0.4686	1.6021
E4 - E1/E2/E3	-2.5200	-0.2466	2.0268
E4 - E7/E8	-3.4847	0.5734	4.6315
E4 - E6	-1.7823	0.8987	3.5797
E7/E8 - E5	-5.0720	-1.0420	2.9879
E7/E8 - E1/E2/E3	-4.9577	-0.8200	3.3178
E7/E8 - E4	-4.6315	-0.5734	3.4847
E7/E8 - E6	-4.0497	0.3253	4.7003
E6 - E5	-4.0056	-1.3673	1.2709
E6 - E1/E2/E3	-3.9454	-1.1453	1.6548
E6 - E4	-3.5797	-0.8987	1.7823
E6 - E7/E8	-4.7003	-0.3253	4.0497

GLM for base of assignment and combined use variable

General Linear Models Procedure
Class Level Information

Class	Levels	Values
BASE	6	Hill Homestead Luke MacDill Moody Shaw

Number of observations in data set = 375

GLM for base of assignment and combined use variable

General Linear Models Procedure

Dependent Variable: USE   Sum of FIM Usefulness Measures

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	546189.22137	91031.53690	3589.60	0.0001
Error	369	9357.77863	25.35983		
Uncorrected Total	375	555547.00000			

R-Square	C.V.	Root MSE	USE Mean
0.004606	13.19576	5.0358548	38.162667

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	546145.92267	546145.92267	21535.86	0.0001
BASE	5	43.29870	8.65974	0.34	0.8876

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	529114.69194	529114.69194	20864.28	0.0001
BASE	5	43.29870	8.65974	0.34	0.8876

GLM for base of assignment and combined use variable

General Linear Models Procedure

Scheffe's test for variable: USE

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than Tukey's for all pairwise comparisons.

Alpha= 0.05 Confidence= 0.95 df= 369 MSE= 25.35983
Critical Value of F= 2.23845

Comparisons significant at the 0.05 level are indicated by '***'.

BASE Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit
Shaw - Luke	-2.5622	0.2959	3.1539
Shaw - Moody	-2.5801	0.5673	3.7147
Shaw - Homestead	-2.1939	0.7419	3.6777
Shaw - Hill	-2.4147	0.7518	3.9183
Shaw - MacDill	-1.8282	0.9723	3.7748
Luke - Shaw	-3.1539	-0.2959	2.5622
Luke - Moody	-2.8666	0.2714	3.4095
Luke - Homestead	-2.4797	0.4460	3.3718
Luke - Hill	-2.7013	0.4560	3.6132
Luke - MacDill	-2.1135	0.6774	3.4684
Moody - Shaw	-3.7147	-0.5673	2.5801
Moody - Luke	-3.4095	-0.2714	2.8666
Moody - Homestead	-3.0344	0.1746	3.3836
Moody - Hill	-3.2368	0.1845	3.6059
Moody - MacDill	-2.6806	0.4060	3.4926
Homestead - Shaw	-3.6777	-0.7419	2.1939
Homestead - Luke	-3.3718	-0.4460	2.4797
Homestead - Moody	-3.3836	-0.1746	3.0344
Homestead - Hill	-3.2178	0.0099	3.2377
Homestead - MacDil	-2.6391	0.2314	3.1019

Scheffe's test for variable: USE cont'd

AFSC Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit
Hill - Shaw	-3.9183	-0.7518	2.4147
Hill - Luke	-3.6132	-0.4560	2.7013
Hill - Moody	-3.6059	-0.1845	3.2368
Hill - Homestead	-3.2377	-0.0099	3.2178
Hill - MacDill	-2.8846	0.2215	3.3276
MacDill - Shaw	-3.7748	-0.9733	1.8282
MacDill - Luke	-3.4684	-0.6774	2.1135
MacDill - Moody	-3.4926	-0.4060	2.6806
MacDill - Homestead	-3.1019	-0.2314	2.6391
MacDill - Hill	-3.3276	-0.2215	2.8846

GLM for education level and combined use variable

General Linear Models Procedure

Class Level Information

Class	Levels	Values
EDUC	3	High School, High School +, Associates Degree or higher

Number of observations in data set = 375

GLM for education level and combined use variable

General Linear Models Procedure

Dependent Variable: USE   Sum of FIM Usefulness Measures

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	546226.54775	182075.51592	7267.04	0.0001
Error	372	9320.45225	25.05498		
Uncorrected Total	375	555547.00000			

R-Square	C.V.	Root MSE	USE Mean
0.008756	13.11621	5.0054949	38.162667

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	546145.92267	546145.92267	21797.90	0.0001
EDUC	2	80.62508	40.31254	1.61	0.2010

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	280033.88014	280033.88014	11176.78	0.0001
EDUC	2	80.62508	40.31254	1.61	0.2010

GLM for education level and combined use variable

General Linear Models Procedure

Scheffe's test for variable: USE

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than Tukey's for all pairwise comparisons.

Alpha= 0.05 Confidence= 0.95 df= 372 MSE= 25.05498
Critical Value of F= 3.01999

Comparisons significant at the 0.05 level are indicated by '***'.

NOTE: High School: A
High School +: B
Associates Degree or higher: C

EDUC Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit
A - B	-0.8448	0.7132	2.2713
A - C	-0.7189	1.8171	4.3531
B - A	-2.2713	-0.7132	0.8448
B - C	-1.1694	1.1038	3.3771
C - A	-4.3531	-1.8171	0.7189
C - B	-3.3771	-1.1038	1.1694

GLM for maintenance experience and combined use variable

General Linear Models Procedure

Class Level Information

Class	Levels	Values
MXEXP	4	+ 12 years, 2 years < 7 years, 7 years < 12 years, < 2 years

Number of observations in data set = 375

GLM for maintenance experience and combined use variable

General Linear Models Procedure

Dependent Variable: USE Sum of FIM Usefulness Measures

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	546159.70432	36539.92608	5396.26	0.0001
Error	371	9387.29568	25.30268		
Uncorrected Total	375	555547.00000			

R-Square	C.V.	Root MSE	USE Mean
0.001466	13.18089	5.0301773	38.162667

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	546145.92267	546145.92267	21584.51	0.0001
MXEXP	3	13.78165	4.59388	0.18	0.9089

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	496022.73583	496022.73583	19603.56	0.0001
MXEXP	3	13.78165	4.59388	0.18	0.9089

GLM for maintenance experience and combined use variable

General Linear Models Procedure

Scheffe's test for variable: USE

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than Tukey's for all pairwise comparisons..

Alpha= 0.05 Confidence= 0.95 df= 371 MSE= 25.30268
Critical Value of F= 2.62897

Comparisons significant at the 0.05 level are indicated by '***'.

NOTE:
- < 2 years: A
- 2 years < 7 years: B
- 7 years < 12 years: C
- 12 years +: D

MXEXP Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit
A - B	-1.8659	0.2692	2.4043
A - C	-1.7025	0.4825	2.6674
A - D	-1.9070	0.5615	3.0301
B - A	-2.4043	-0.2692	1.8659
B - C	-1.5994	0.2132	2.0258
B - D	-1.8537	0.2923	2.4383
C - A	-2.6674	-0.4825	1.7025
C - B	-2.0258	-0.2132	1.5994
C - D	-2.1165	0.0791	2.2747
D - A	-3.0301	-0.5615	1.9070
D - B	-2.4383	-0.2923	1.8537
D - C	-2.2747	-0.0791	2.1165

GLM for F-16 experience and combined use variable

General Linear Models Procedure

Class Level Information

Class	Levels	Values
F16EXP	3	2 years < 7 years, 7 years or more, < 2 years

Number of observations in data set = 375

GLM for F-16 experience and combined use variable

General Linear Models Procedure

Dependent Variable: USE   Sum of FIM Usefulness Measures

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	546154.09212	182051.36404	7210.03	0.0001
Error	372	9392.90788	25.24975		
Uncorrected Total	375	555547.00000			

R-Square	C.V.	Root MSE	USE Mean
0.000869	13.16709	5.0249132	38.162667

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	546145.92267	546145.92267	21629.75	0.0001
F16EXP	2	8.16945	4.08473	0.16	0.8507

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	461338.59060	461338.59060	18271.01	0.0001
F16EXP	2	8.16945	4.08473	0.16	0.8507

GLM for F-16 experience and combined use variable

General Linear Models Procedure

Scheffe's test for variable: USE

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than Tukey's for all pairwise comparisons..

Alpha= 0.05 Confidence= 0.95 df= 372 MSE= 25.24975
Critical Value of F= 3.01999

Comparisons significant at the 0.05 level are indicated by '***'.

NOTE: < 2 years: A
2 years < 7 years: B
7 years or more: C

F16EXP Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit
A - B	-1.2007	0.2662	1.7331
A - C	-1.4780	0.4036	2.2852
B - A	-1.7331	-0.2662	1.2007
B - C	-1.5857	0.1374	1.8604
C - A	-2.2852	-0.4036	1.4780
C - B	-1.8604	-0.1374	1.5857

GLM for FIM experience and combined use variable

General Linear Models Procedure

Class Level Information

Class	Levels	Values
FIMEXP	3	2 years < 7 years, 7 years or more, < 2 years,

Number of observations in data set = 375

GLM for FIM experience and combined use variable
General Linear Models Procedure

Dependent Variable: USE-Sum of FIM Usefulness Measures

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	546178.73026	182059.57675	7229.31	0.0001
Error	372	9368.26974	25.18352		
Uncorrected Total	375	555547.00000			

R-Square	C.V.	Root MSE	USE Mean
0.003490	13.14981	5.0183185	38.162667

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	546145.92267	546145.92267	21686.64	0.0001
FIMEXP	2	32.80759	16.40380	0.65	0.5219

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	419672.59186	419672.59186	16664.57	0.0001
FIMEXP	2	32.80759	16.40380	0.65	0.5219

GLM for FIM experience and combined use variable

General Linear Models Procedure

Scheffe's test for variable: USE

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than Tukey's for all pairwise comparisons.

Alpha= 0.05 Confidence= 0.95 df= 372 MSE= 25.18352
Critical Value of F= 3.01999

Comparisons significant at the 0.05 level are indicated by '***'.

NOTE: < 2 years: A
2 years < 7 years: B
7 years or more: C

FIMEXP Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit
A - B	-1.2220	0.1548	1.5316
A - C	-1.0470	0.8955	2.8381
B - A	-1.5316	-0.1548	1.2220
B - C	-1.1972	0.7407	2.6787
C - A	-2.8381	-0.8955	1.0470
C - B	-2.6787	-0.7407	1.1972

Appendix K: ANOVA and Scheffe Means Test Results for Research Hypothesis 3.2

GLM for skill level and combined accuracy variable
General Linear Models Procedure

Class Level Information

Class	Levels	Values
SKILL	3	3, 5, 7/9

Number of observations in data set = 375

GLM for skill level and combined accuracy variable
General Linear Models Procedure

Dependent Variable: ACC   Sum of FIM Accuracy Measures

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	789281.14984	263093.71661	4127.51	0.0001
Error	372	23711.85016	63.74153		
Uncorrected Total	375	812993.00000			

R-Square	C.V.	Root MSE	ACC Mean
0.041106	17.41369	7.9838294	45.848000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	788264.66400	788264.66400	12366.58	0.0001
SKILL	2	1016.48584	508.24292	7.97	0.0004

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	591780.02865	591780.02865	9284.06	0.0001
SKILL	2	1016.48584	508.24292	7.97	0.0004

GLM for skill level and combined accuracy variable
General Linear Models Procedure

Scheffe's test for variable: ACC

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than Tukey's for all pairwise comparisons.

Alpha= 0.05 Confidence= 0.95 df= 372 MSE= 63.74153
Critical Value of F= 3.01999

Comparisons significant at the 0.05 level are indicated by '***'.

SKILL Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
3 - 5	-2.4166	0.7918	4.0002	
3 - 7/9	0.6910	3.8767	7.0624	***
5 - 3	-4.0002	-0.7918	2.4166	
5 - 7/9	0.910 4	3.0849	5.2594	***
7/9 - 3	-7.0624	-3.8767	-0.6910	***
7/9 - 5	-5.2594	-3.0849	-0.9104	***

GLM for grade and combined accuracy variable
General Linear Models Procedure

Class Level Information

Class	Levels	Values
GRADE	5	E1/E2/E3, E4, E5, E6, E7/E8

Number of observations in data set = 375

GLM for grade and combined accuracy variable

General Linear Models Procedure

Dependent Variable: ACC   Sum of FIM Accuracy Measures

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	789273.02325	157854.60465	2462.32	0.0001
Error	370	23719.97675	64.10805		
Uncorrected Total	375	812993.00000			

R-Square	C.V.	Root MSE	ACC Mean
0.040777	17.46368	8.0067500	45.848000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	788264.66400	788264.66400	12295.88	0.0001
GRADE	4	1008.35925	252.08981	3.93	0.0039

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	469312.39385	469312.39385	7320.65	0.0001
GRADE	4	1008.35925	252.08981	3.93	0.0039

GLM for grade and combined accuracy variable

General Linear Models Procedure

Scheffe's test for variable: ACC

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than Tukey's for all pairwise comparisons.

Alpha= 0.05 Confidence= 0.95 df= 370 MSE= 64.10805
Critical Value of F= 2.39607

Comparisons significant at the 0.05 level are indicated by '***'.

GRADE Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit
E1/E2/E3 - E4	-3.138	0.488	4.113
E1/E2/E3 - E6	-1.403	3.062	7.528
E1/E2/E3 - E5	-0.248	3.297	6.841
E1/E2/E3 - E7/E8	-1.277	5.322	11.921
E4 - E1,E2,E3	-4.113	-0.488	3.138
E4 - E6	-1.701	2.575	6.850
E4 - E5	-0.494	2.809	6.111
E4 - E7/E8	-1.638	4.834	11.306
E6 - E1/E2/E3	-7.528	-3.062	1.403
E6 - E4	-6.850	-2.575	1.701
E6 - E5	-3.973	0.234	4.442
E6 - E7/E8	-4.718	2.259	9.237
E5 - E1/E2/E3	-6.841	-3.297	0.248
E5 - E4	-6.111	-2.809	0.494
E5 - E6	-4.442	-0.234	3.973
E5 - E7/E8	-4.402	2.025	8.452
E7/E8 - E1/E2/E3	-11.921	-5.322	1.277
E7/E8 - E4	-11.306	-4.834	1.638
E7/E8 - E6	-9.237	-2.259	4.718
E7/E8 - E5	-8.452	-2.025	4.402

GLM for afsc and combined accuracy variables
General Linear Models Procedure

Class Level Information

Class	Levels	Values
AFSC	7	45272 452X5 452X2A 452X2B 452X2C 452X4B 462X0

Number of observations in data set = 375

GLM for afsc and combined accuracy variables

General Linear Models Procedure

Dependent Variable: ACC   Sum of FIM Accuracy Measures

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	790804.79568	112972.11367	1873.69	0.0001
Error	368	22188.20432	60.29403		
Uncorrected Total	375	812993.00000			

R-Square	C.V.	Root MSE	ACC Mean
0.102721	16.93623	7.7649233	45.848000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	788264.66400	788264.66400	13073.68	0.0001
AFSC	6	2540.13168	423.35528	7.02	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	386013.32750	386013.32750	6402.18	0.0001
AFSC	6	2540.13168	423.35528	7.02	0.0001

GLM for afsc and combined accuracy variables

General Linear Models Procedure

Scheffe's test for variable: ACC

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than Tukey's for all pairwise comparisons.

Alpha= 0.05 Confidence= 0.95 df= 368 MSE= 60.29403
Critical Value of F= 2.12323

Comparisons significant at the 0.05 level are indicated by '***'.

AFSC Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
462X0 - 452X4B	-3.1187	0.3554	3.8296	
462X0 - 452X2C	-6.4598	0.5869	7.6335	
462X0 - 452X5	-3.3911	2.2446	7.8802	
462X0 - 452X2B	-2.3915	3.7491	9.8897	
462X0 - 452X2A	-2.4189	4.9966	12.4121	
462X0 - 45272	3.7734	10.0174	16.2614	***
452X4B - 462X0	-3.8296	-0.3554	3.1187	
452X4B - 452X2C	-6.6794	0.2314	7.1422	
452X4B - 452X5	-3.5757	1.8891	7.3540	
452X4B - 452X2B	-2.5906	3.3936	9.3779	
452X4B - 452X2A	-2.6454	4.6411	11.9277	
452X4B - 45272	3.5717	9.6620	15.7522	***
452X2C - 462X0	-7.6335	-0.5869	6.4598	
452X2C - 452X4B	-7.1422	-0.2314	6.6794	
452X2C - 452X5	-6.5551	1.6577	9.8705	
452X2C - 452X2B	-5.4050	3.1622	11.7294	
452X2C - 452X2A	-5.1129	4.4097	13.9323	
452X2C - 45272	0.7890	9.4306	18.0722	***
452X5 - 462X0	-7.8802	-2.2446	3.3911	
452X5 - 452X4B	-7.3540	-1.8891	3.5757	
452X5 - 452X2C	-9.8705	-1.6577	6.5551	
452X5 - 452X2B	-5.9455	1.5045	8.9545	
452X5 - 452X2A	-5.7794	2.7520	11.2834	
452X5 - 45272	0.2375	7.7728	15.3082	***

Scheffe's test for variable: ACC cont'd

AFSC Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
452X2B - 462X0	-9.8897	-3.7491	2.3915	
452X2B - 452X4B	-9.3779	-3.3936	2.5906	
452X2B - 452X2C	-11.7294	-3.1622	5.4050	
452X2B - 452X5	-8.9545	-1.5045	5.9455	
452X2B - 452X2A	-7.6256	1.2475	10.1206	
452X2B - 45272	-1.6518	6.2683	14.1885	
452X2A - 462X0	-12.4121	-4.9966	2.4189	
452X2A - 452X4B	-11.9277	-4.6411	2.6454	
452X2A - 452X2C	-13.9323	-4.4097	5.1129	
452X2A - 452X5	-11.2834	-2.7520	5.7794	
452X2A - 452X2B	-10.1206	-1.2475	7.6256	
452X2A - 45272	-3.9241	5.0208	13.9657	
45272 - 462X0	-16.2614	-10.0174	-3.7734	***
45272 - 452X4B	-15.7522	-9.6620	-3.5717	***
45272 - 452X2C	-18.0722	-9.4306	-0.7890	***
45272 - 452X5	-15.3082	-7.7728	-0.2375	***
45272 - 452X2B	-14.1885	-6.2683	1.6518	
45272 - 452X2A	-13.9657	-5.0208	3.9241	

GLM for base of assignment and combined accuracy variable

General Linear Models Procedure
Class Level Information

Class	Levels	Values
BASE	6	Hill Homestead Luke MacDill Moody Shaw

Number of observations in data set = 375

GLM for base of assignment and combined accuracy variable

General Linear Models Procedure

Dependent Variable: ACC   Sum of FIM Accuracy Measures

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	788508.83339	131418.13890	1980.60	0.0001
Error	369	24484.16661	66.35276		
Uncorrected Total	375	812993.00000			

R-Square	C.V.	Root MSE	ACC Mean
0.009874	17.76679	8.1457200	45.848000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	788264.66400	788264.66400	11879.91	0.0001
BASE	5	244.16939	48.83388	0.74	0.5969

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	763920.87309	763920.87309	11513.02	0.0001
BASE	5	244.16939	48.83388	0.74	0.5969

GLM for base of assignment and combined accuracy variable
General Linear Models Procedure

Scheffe's test for variable: ACC

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than Tukey's for all pairwise comparisons.

Alpha= 0.05 Confidence= 0.95 df= 369 MSE= 66.35276
Critical Value of F= 2.23845

Comparisons significant at the 0.05 level are indicated by '***'.

BASE Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit
MacDill - Moody	-4.122	0.871	5.864
MacDill - Hill	-3.681	1.343	6.367
MacDill - Homestead	-3.017	1.626	6.269
MacDill - Luke	-2.560	1.955	6.469
MacDill - Shaw	-2.218	2.313	6.845
Moody - MacDill	-5.864	-0.871	4.122
Moody - Hill	-5.062	0.472	6.007
Moody - Homestead	-4.436	0.755	5.946
Moody - Luke	-3.992	1.084	6.160
Moody - Shaw	-3.649	1.442	6.534
Hill - MacDill	-6.367	-1.343	3.681
Hill - Moody	-6.007	-0.472	5.062
Hill - Homestead	-4.938	0.283	5.504
Hill - Luke	-4.496	0.611	5.718
Hill - Shaw	-4.152	0.970	6.092
Homestead - MacDill	-6.269	-1.626	3.017
Homestead - Moody	-5.946	-0.755	4.436
Homestead - Hill	-5.504	-0.283	4.938
Homestead - Luke	-4.404	0.329	5.061
Homestead - Shaw	-4.061	0.687	5.436
Luke - MacDill	-6.469	-1.955	2.560
Luke - Moody	-6.160	-1.084	3.992
Luke - Hill	-5.718	-0.611	4.496
Luke - Homestead	-5.061	-0.329	4.404
Luke - Shaw	-4.264	0.359	4.982

Scheffe's test for variable: ACC cont'd

BASE Comparison			Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit
Shaw	-	MacDill	-6.845	-2.313	2.218
Shaw	-	Moody	-6.534	-1.442	3.649
Shaw	-	Hill	-6.092	-0.970	4.152
Shaw	-	Homestead	-5.436	-0.687	4.061
Shaw	-	Luke	-4.982	-0.359	4.264

GLM for mx experience and combined accuracy variable
General Linear Models Procedure

Class Level Information

Class	Levels	Values
MXEXP	4	+ 12 years, 2 years < 7 years, 7 years < 12 years, < 2 years

Number of observations in data set = 375

GLM for mx experience and combined accuracy variable
General Linear Models Procedure

Dependent Variable: ACC   Sum of FIM Accuracy Measures

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	789156.49863	197289.12466	3070.68	0.0001
Error	371	23836.50137	64.24933		
Uncorrected Total	375	812993.00000			

R-Square	C.V.	Root MSE	ACC Mean
0.036065	17.48292	8.0155680	45.848000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	788264.66400	788264.66400	12268.84	0.0001
MXEXP	3	891.83463	297.27821	4.63	0.0034

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	717190.86680	717190.86680	11162.62	0.0001
MXEXP	3	891.83463	297.27821	4.63	0.0034

GLM for mx experience and combined accuracy variable
General Linear Models Procedure

Scheffe's test for variable: ACC

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than Tukey's for all pairwise comparisons..

Alpha= 0.05 Confidence= 0.95 df= 371 MSE= 64.24933
Critical Value of F= 2.62897

Comparisons significant at the 0.05 level are indicated by '***'.

NOTE: < 2 years: A
2 years < 7 years: B
7 years < 12 years: C
12 years +: D

MXEXP Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
A - B	-2.9342	0.4681	3.8704	
A - D	-1.4040	2.5296	6.4632	
A - C	0.2256	3.7073	7.1891	***
B - A	-3.8704	-0.4681	2.9342	
B - D	-1.3581	2.0615	5.4811	
B - C	0.3509	3.2393	6.1277	***
D - A	-6.4632	-2.5296	1.4040	
D - C	-5.4811	-2.0615	1.3581	
D - B	-2.3210	1.1777	4.6764	
C - A	-7.1891	-3.7073	-0.2256	***
C - B	-6.1277	-3.2393	-0.3509	***
C - D	-4.6764	-1.1777	2.3210	

GLM for f16 experience and combined accuracy variables
General Linear Models Procedure

Class Level Information

Class	Levels	Values
F16EXP	3	< 2 years, 2 years < 7 years, 7 years or more

Number of observations in data set = 375

GLM for F-16 experience and combined accuracy variables
General Linear Models Procedure

Dependent Variable: ACC Sum of FIM Accuracy Measures

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	789131.44323	263043.81441	4100.83	0.0001
Error	372	23861.55677	64.14397		
Uncorrected Total	375	812993.00000			

R-Square	C.V.	Root MSE	ACC Mean
0.035052	17.46858	8.0089931	45.848000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	788264.66400	788264.66400	12288.99	0.0001
F16EXP	2	866.77923	433.38961	6.76	0.0013

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	656232.22454	656232.22454	10230.61	0.0001
F16EXP	2	866.77923	433.38961	6.76	0.0013

GLM for F-16 experience and combined accuracy variables
General Linear Models Procedure

Scheffe's test for variable: ACC

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than Tukey's for all pairwise comparisons.

Alpha= 0.05 Confidence= 0.95 df= 372 MSE= 64.14397
Critical Value of F= 3.01999

Comparisons significant at the 0.05 level are indicated by '***'.

NOTE: < 2 years: A
2 years < 7 years: B
7 years or more: C

F16EXP Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
A - B	-0.6164	1.7217	4.0598	
A - C	1.4867	4.4857	7.4847	***
B - A	-4.0598	-1.7217	0.6164	
B - C	0.0177	2.7640	5.5103	***
C - A	-7.4847	-4.4857	-1.4867	***
C - B	-5.5103	-2.7640	-0.0177	***

GLM for FIM experience and combined accuracy variable
General Linear Models Procedure

Class Level Information

Class	Levels	Values
FIMEXP	3	< 2 years, 2 years < 7 years, 7 years or more

Number of observations in data set = 375

GLM for FIM experience and combined accuracy variable

General Linear Models Procedure

Dependent Variable: ACC Sum of FIM Accuracy Measures

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	789871.00617	263290.33539	4235.97	0.0001
Error	372	23121.99383	62.15590		
Uncorrected Total	375	812993.00000			

R-Square	C.V.	Root MSE	ACC Mean
0.064960	17.19574	7.8839012	45.848000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	788264.66400	788264.66400	12682.06	0.0001
FIMEXP	2	1606.34217	803.17109	12.92	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	589185.01710	589185.01710	9479.15	0.0001
FIMEXP	2	1606.34217	803.17109	12.92	0.0001

GLM for FIM experience and combined accuracy variable
General Linear Models Procedure

Scheffe's test for variable: ACC

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than Tukey's for all pairwise comparisons.,

Alpha= 0.05 Confidence= 0.95 df= 372 MSE= 62.1559
Critical Value of F= 3.01999

Comparisons significant at the 0.05 level are indicated by '***'.

NOTE: < 2 years: A
2 years < 7 years: B
7 years or more: C

FIMEXP Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
A - B	0.8617	3.0247	5.1877	***
A - C	2.8186	5.8704	8.9221	***
B - A	-5.1877	-3.0247	-0.8617	***
B - C	-0.1989	2.8457	5.8903	
C - A	-8.9221	-5.8704	-2.8186	***
C - B	-5.8903	-2.8457	0.1989	

Appendix L: ANOVA and Scheffe Means Test Results for Research Hypothesis 4.1

glm for combined use variables and fimuse

General Linear Models Procedure
Class Level Information

Class	Levels	Values
FIMUSE	4	0 - 25 percent, 26 - 50 percent, 51 - 75 percent, 76 - 100 percent

Number of observations in data set = 375

General Linear Models Procedure

Dependent Variable: USE - Sum of FIM Usefulness Measures

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	546545.03088	136636.25772	5631.22	0.0001
Error	371	9001.96912	24.26407		
Uncorrected Total	375	555547.00000			

R-Square	C.V.	Root MSE	USE Mean
0.042453	12.90753	4.9258571	38.162667

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	546145.92267	546145.92267	22508.42	0.0001
FIMUSE	3	399.10822	133.03607	5.48	0.0011

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	521772.65500	521772.65500	21503.92	0.0001
FIMUSE	3	399.10822	133.03607	5.48	0.0011

glm for combined use variables and fimuse

General Linear Models Procedure

Scheffe's test for variable: USE

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than Tukey's for all pairwise comparisons.

Alpha= 0.05 Confidence= 0.95 df= 371 MSE= 24.26407
Critical Value of F= 2.62897

Comparisons significant at the 0.05 level are indicated by '***'.

NOTE: 76 - 100: A
51 - 75: B
26 - 50: C
0 - 25: D

FIMUSE Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
A - B	-1.1101	1.1199	3.3500	
A - D	0.3050	2.3600	4.4151	***
A - C	0.6140	2.8441	5.0741	***
B - A	-3.3500	-1.1199	1.1101	
B - D	-0.6703	1.2401	3.1504	
B - C	-0.3733	1.7241	3.8216	
D - A	-4.4151	-2.3600	-0.3050	***
D - B	-3.1504	-1.2401	0.6703	
D - C	-1.4263	0.4841	2.3944	
C - A	-5.0741	-2.8441	-0.6140	***
C - B	-3.8216	-1.7241	0.3733	
C - D	-2.3944	-0.4841	1.4263	

Appendix M: ANOVA and Scheffe Means Test Results for Research Hypothesis 4.2

glm for combined accuracy variables and fimuse
General Linear Models Procedure

Class Level Information

Class	Levels	Values
FIMUSE	4	0 - 25 percent, 26 - 50 percent, 51 - 75 76 - 100 percent

Number of observations in data set = 375

General Linear Models Procedure
Dependent Variable: ACC Sum of FIM Accuracy Measures

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	789579.40969	197394.85242	3127.82	0.0001
Error	371	23413.59031	63.10941		
Uncorrected Total	375	812993.00000			

R-Square	C.V.	Root MSE	ACC Mean
0.053168	17.32713	7.9441430	45.848000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	788264.66400	788264.66400	12490.45	0.0001
FIMUSE	3	1314.74569	438.24856	6.94	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	750549.09101	750549.09101	11982.82	0.0001
FIMUSE	3	1314.74569	438.24856	6.94	0.0001

GLM for combined accuracy variables and fimuse

General Linear Models Procedure

Scheffe's test for variable: ACC

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than Tukey's for all pairwise comparisons.

Alpha= 0.05 Confidence= 0.95 df= 371 MSE= 63.1-941
Critical Value of F= 2.62897

Comparisons significant at the 0.05 level are indicated by '***'.

NOTE: 76 - 100: A
51 - 75: B
26 - 50: C
0 - 25: D

FIMUSE Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
A - B	-2.0243	1.5722	5.1687	
A - D	-0.8238	2.4904	5.8047	
A - C	1.9527	5.5492	9.1457	***
B - A	-5.1687	-1.5722	2.0243	
B - D	-2.1627	0.9182	3.9991	
B - C	0.5944	3.9770	7.3597	***
D - A	-5.8047	-2.4904	0.8238	
D - B	-3.9991	-0.9182	2.1627	
D - C	-0.0221	3.0588	6.1397	
C - A	-9.1457	-5.5492	-1.9527	***
C - B	-7.3597	-3.9770	-0.5944	***
C - D	-6.1397	-3.0588	0.0221	

Appendix N: ANOVA and Scheffe Means Test for Research Hypothesis 5.1

GLM for skill level and satisfaction

General Linear Models Procedure
Class Level Information

Class	Levels	Values
SKILL	3	3 5 7 and 9

Number of observations in data set = 375

GLM for skill level and satisfaction

General Linear Models Procedure

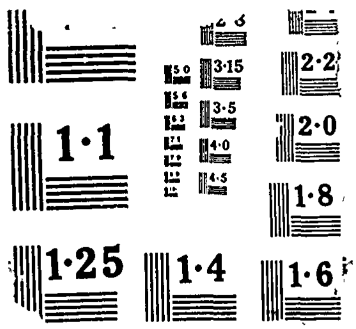
Dependent Variable: Satisfaction

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	3180.6774735	1060.2258245	1331.00	0.0001
Error	372	296.3225265	0.7965659		
Uncorrected Total	375	3477.0000000			

R-Square	C.V.	Root MSE	SatisfactionMean
0.021771	30.67732	0.8925054	2.9093333

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	3174.0826667	3174.0826667	3984.71	0.0001
SKILL	2	6.5948069	3.2974034	4.14	0.0167

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	2436.7683292	2436.7683292	3059.09	0.0001
SKILL	2	6.5948069	3.2974034	4.14	0.0167


3·15
3·5
4·0
4·5
2·2
2·0
1·8
1·1
1·25
1·4
1·6

GLM for skill level and satisfaction

General Linear Models Procedure

Scheffe's test for variable: Satisfaction

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than Tukey's for all pairwise comparisons.

Alpha= 0.05 Confidence= 0.95 df= 372 MSE= 0.796566
Critical Value of F= 3.01999

Comparisons significant at the 0.05 level are indicated by 'xxx'.

SKILL Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
3 - 5	-0.13069	0.22798	0.58664	
3 - 7/9	0.04183	0.39796	0.75409	xxx
5 - 3	-0.58664	-0.22798	0.13069	
5 - 7/9	-0.07310	0.16998	0.41306	
7/9 - 3	-0.75409	-0.39796	-0.04183	xxx
7/9 - 5	-0.41306	-0.16998	0.07310	

GLM for afsc and satisfaction

General Linear Models Procedure
Class Level Information

Class	Levels	Values
AFSC	7	45272 452X5 452X2A 452X2B 452X2C 452X4B 462X0

Number of observations in data set = 375

GLM for afsc and satisfaction
General Linear Models Procedure

Dependent Variable: Satoisfaction

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	3195.5853998	456.5122000	596.97	0.0001
Error	368	281.4146002	0.7647136		
Uncorrected Total	375	3477.0000000			

R-Square	C.V.	Root MSE	Satisfaction Mean
0.070985	30.05771	0.8744790	2.9093333

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	3174.0826667	3174.0826667	4150.68	0.0001
AFSC	6	21.5027332	3.5837889	4.69	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	1563.3103549	1563.3103549	2044.31	0.0001
AFSC	6	21.5027332	3.5837889	4.69	0.0001

GLM for afsc and satisfaction

General Linear Models Procedure

Scheffe's test for variable: Satisfaction

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than Tukey's for all pairwise comparisons.

Alpha= 0.05 Confidence= 0.95 df= 368 MSE= 0.764714
Critical Value of F= 2.12323

Comparisons significant at the 0.05 level are indicated by '***'.

AFSC Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
452X2C - 452X4B	-0.6514	0.1269	0.9052	
452X2C - 452X2B	-0.7582	0.2067	1.1715	
452X2C - 452X5	-0.6615	0.2634	1.1884	
452X2C - 462X0	-0.5269	0.2667	1.0603	
452X2C - 452X2A	-0.5308	0.5417	1.6141	
452X2C - 45272	0.1101	1.0833	2.0565	***
452X4B - 452X2C	-0.9052	-0.1269	0.6514	
452X4B - 452X2B	-0.5942	0.0797	0.7537	
452X4B - 452X5	-0.4789	0.1365	0.7520	
452X4B - 462X0	-0.2515	0.1397	0.5310	
452X4B - 452X2A	-0.4059	0.4147	1.2353	
452X4B - 45272	0.2705	0.9564	1.6423	***
452X2B - 452X2C	-1.1715	-0.2067	0.7582	
452X2B - 452X4B	-0.7537	-0.0797	0.5942	
452X2B - 452X5	-0.7822	0.0568	0.8958	
452X2B - 462X0	-0.6316	0.0600	0.7516	
452X2B - 452X2A	-0.6643	0.3350	1.3343	
452X2B - 45272	-0.0153	0.8767	1.7686	
452X5 - 452X2C	-1.1884	-0.2634	0.6615	
452X5 - 452X4B	-0.7520	-0.1365	0.4789	
452X5 - 452X2B	-0.8958	-0.0568	0.7822	
452X5 - 462X0	-0.6315	0.0032	0.6379	
452X5 - 452X2A	-0.6826	0.2782	1.2390	
452X5 - 45272	-0.0287	0.8199	1.6685	

Scheffe's test for variable: Satisfaction

AFSC Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
462X0 - 452X2C	-1.0603	-0.2667	0.5269	
462X0 - 452X4B	-0.5310	-0.1397	0.2515	
462X0 - 452X2B	-0.7516	-0.0600	0.6316	
462X0 - 452X5	-0.6379	-0.0032	0.6315	
462X0 - 452X2A	-0.5601	0.2750	1.1101	
462X0 - 45272	0.1135	0.8167	1.5199	***
452X2A - 452X2C	-1.6141	-0.5417	0.5308	
452X2A - 452X4B	-1.2353	-0.4147	0.4059	
452X2A - 452X2B	-1.3343	-0.3350	0.6643	
452X2A - 452X5	-1.2390	-0.2782	0.6826	
452X2A - 462X0	-1.1101	-0.2750	0.5601	
452X2A - 45272	-0.4657	0.5417	1.5490	
45272 - 452X2C	-2.0565	-1.0833	-0.1101	***
45272 - 452X4B	-1.6423	-0.9564	-0.2705	***
45272 - 452X2B	-1.7686	-0.8767	0.0153	
45272 - 452X5	-1.6685	-0.8199	0.0287	
45272 - 462X0	-1.5199	-0.8167	-0.1135	***
45272 - 452X2A	-1.5490	-0.5417	0.4657	

GLM for grade and satisfaction
General Linear Models Procedure

Class Level Information

Class	Levels	Values
GRADE	5	E1,E2,E3 E4 E5 E6 E7/E8

Number of observations in data set = 375

GLM for grade and satisfaction
General Linear Models Procedure

Dependent Variable: Satisfaction

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	3182.1331357	636.4266271	798.59	0.0001
Error	370	294.8668643	0.7969375		
Uncorrected Total	375	3477.0000000			

R-Square	C.V.	Root MSE	SatisfactionMean
0.026576	30.68447	0.8927135	2.9093333

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	3174.0826667	3174.0826667	3982.85	0.0001
GRADE	4	8.0504690	2.0126173	2.53	0.0405

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	1826.8525244	1826.8525244	2292.34	0.0001
GRADE	4	8.0504690	2.0126173	2.53	0.0405

GLM for grade and satisfaction
General Linear Models Procedure

Scheffe's test for variable: Satisfaction

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than Tukey's for all pairwise comparisons.

Alpha= 0.05 Confidence= 0.95 df= 370 MSE= 0.796937
Critical Value of F= 2.39607

Comparisons significant at the 0.05 level are indicated by '***'.

GRADE Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit
E1,E2,E3 - E5	-0.2148	0.1804	0.5757
E1,E2,E3 - E4	-0.2237	0.1805	0.5847
E1,E2,E3 - E6	-0.1158	0.3821	0.8800
E1,E2,E3 - E7/E8	-0.1099	0.6258	1.3615
E5 - E1,E2,E3	-0.5757	-0.1804	0.2148
E5 - E4	-0.3681	0.0001	0.3683
E5 - E6	-0.2674	0.2017	0.6708
E5 - E7/E8	-0.2712	0.4454	1.1620
E4 - E1,E2,E3	-0.5847	-0.1805	0.2237
E4 - E5	-0.3683	-0.0001	0.3681
E4 - E6	-0.2751	0.2016	0.6783
E4 - E7/E8	-0.2763	0.4453	1.1669
E6 - E1,E2,E3	-0.8800	-0.3821	0.1158
E6 - E5	-0.6708	-0.2017	0.2674
E6 - E4	-0.6783	-0.2016	0.2751
E6 - E7/E8	-0.5342	0.2437	1.0216
E7/E8 - E1,E2,E3	-1.3615	-0.6258	0.1099
E7/E8 - E5	-1.1620	-0.4454	0.2712
E7/E8 - E4	-1.1669	-0.4453	0.2763
E7/E8 - E6	-1.0216	-0.2437	0.5342

GLM for base of assignment and satisfaction
General Linear Models Procedure

Class Level Information

Class	Levels	Values
BASE	6	Hill Homestead Luke MacDill Moody Shaw

Number of observations in data set = 375

GLM for base of assignment and satisfaction

General Linear Models Procedure

Dependent Variable: Satisfaction

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	3180.8783273	530.1463879	660.62	0.0001
Error	369	296.1216727	0.8024978		
Uncorrected Total	375	3477.0000000			

R-Square	C.V.	Root MSE	Satisfaction Mean
0.022434	30.79133	0.8958224	2.9093333

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	3174.0826667	3174.0826667	3955.25	0.0001
BASE	5	6.7956606	1.3591321	1.69	0.1352

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	3076.1289827	3076.1289827	3833.19	0.0001
BASE	5	6.7956606	1.3591321	1.69	0.1352

GLM for base of assignment and satisfaction
General Linear Models Procedure

Scheffe's test for variable: Satisfaction

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than Tukey's for all pairwise comparisons.

Alpha= 0.05 Confidence= 0.95 df= 369 MSE= 0.802498
Critical Value of F= 2.23845

Comparisons significant at the 0.05 level are indicated by '***'.

BASE Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit
MacDill - Moody	-0.4846	0.0644	0.6135
MacDill - Homestead	-0.3419	0.1688	0.6794
MacDill - Hill	-0.2806	0.2719	0.8245
MacDill - Luke	-0.1626	0.3338	0.8303
MacDill - Shaw	-0.1612	0.3371	0.8355
Moody - MacDill	-0.6135	-0.0644	0.4846
Moody - Homestead	-0.4665	0.1043	0.6752
Moody - Hill	-0.4011	0.2075	0.8161
Moody - Luke	-0.2888	0.2694	0.8276
Moody - Shaw	-0.2872	0.2727	0.8326
Homestead - MacDill	-0.6794	-0.1688	0.3419
Homestead - Moody	-0.6752	-0.1043	0.4665
Homestead - Hill	-0.4710	0.1032	0.6774
Homestead - Luke	-0.3554	0.1651	0.6855
Homestead - Shaw	-0.3539	0.1684	0.6906
Hill - MacDill	-0.8245	-0.2719	0.2806
Hill - Moody	-0.8161	-0.2075	0.4011
Hill - Homestead	-0.6774	-0.1032	0.4710
Hill - Luke	-0.4997	0.0619	0.6235
Hill - Shaw	-0.4981	0.0652	0.6285
Luke - MacDill	-0.8303	-0.3338	0.1626
Luke - Moody	-0.8276	-0.2694	0.2888
Luke - Homestead	-0.6855	-0.1651	0.3554
Luke - Hill	-0.6235	-0.0619	0.4997
Luke - Shaw	-0.5051	0.0033	0.5117

Scheffe's test for variable: Satisfaction

BASE Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit
Shaw - MacDill	-0.8355	-0.3371	0.1612
Shaw - Moody	-0.8326	-0.2727	0.2872
Shaw - Homestead	-0.6906	-0.1684	0.3539
Shaw - Hill	-0.6285	-0.0652	0.4981
Shaw - Luke	-0.5117	-0.0033	0.5051

GLM for education and satisfaction
General Linear Models Procedure

Class Level Information

Class	Levels	Values
EDUC	3	Associate Degree or higher, high school, high school +

Number of observations in data set = 375

GLM for education and satisfaction
General Linear Models Procedure

Dependent Variable: Satisfaction

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	3181.1343027	1060.3781009	1333.24	0.0001
Error	372	295.8656973	0.7953379		
Uncorrected Total	375	3477.0000000			

R-Square	C.V.	Root MSE	Satisfaction Mean
0.023279	30.65366	0.8918172	2.9093333

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	3174.0826667	3174.0826667	3990.86	0.0001
EDUC	2	7.0516360	3.5258180	4.43	0.0125

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	1625.1079578	1625.1079578	2043.29	0.0001
EDUC	2	7.0516360	3.5258180	4.43	0.0125

General Linear Models Procedure
Scheffe's test for variable: Satisfaction

NOTE: This test controls the type I experimentwise error rate
but generally has a higher type II error rate
than Tukey's for all pairwise comparisons.

Alpha= 0.05 Confidence= 0.95 df= 372 MSE= 0.795338
Critical Value of F= 3.01999

Comparisons significant at the 0.05 level are indicated by '***'.

NOTE: High School: A
High School +: B
Associates Degree or higher: C

EDUC Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
A - B	0.00336	0.28096	0.55855	***
A - C	0.02784	0.47967	0.93151	***
B - A	-0.55855	-0.28096	-0.00336	***
B - C	-0.20631	0.19872	0.60374	
C - A	-0.93151	-0.47967	-0.02784	***
C - B	-0.60374	-0.19872	0.20631	

GLM for maintenance experience and satisfaction
General Linear Models Procedure

Class Level Information

Class	Levels	Values
MXEXP	4	+ 12 years, 2 years < 7 years, 7 years < 12 years, < 2 years

Number of observations in data set = 375

GLM for maintenance experience and satisfaction
General Linear Models Procedure

Dependent Variable: Satisfaction

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	3181.2234940	795.3058735	997.57	0.0001
Error	371	295.7765060	0.7972413		
Uncorrected Total	375	3477.0000000			

R-Square	C.V.	Root MSE	Satisfaction Mean
0.023574	30.69032	0.8928837	2.9093333

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTFRCEPT	1	3174.0826667	3174.0826667	3981.33	0.0001
MXEXP	3	7.1408274	2.3802758	2.99	0.0312

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	2877.2598988	2877.2598988	3609.02	0.0001
MXEXP	3	7.1408274	2.3802758	2.99	0.0312

GLM for maintenance experience and satisfaction
General Linear Models Procedure

Scheffe's test for variable: Satisfaction

NOTE: This test controls the type I experimentwise error rate
but generally has a higher type II error rate
than Tukey's for all pairwise comparisons.

Alpha= 0.05 Confidence= 0.95 df= 371 MSE= 0.797241
Critical Value of F= 2.62897

Comparisons significant at the 0.05 level are indicated by '***'.

NOTE: < 2 years: A
2 years < 7 years: B
7 years > 12 years: C
12 years or more: D

MXEXP Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
A - B	-0.1811	0.1979	0.5769	
A - C	-0.1287	0.2592	0.6470	
A - D	0.0213	0.4594	0.8976	***
B - A	-0.5769	-0.1979	0.1811	
B - C	-0.2605	0.0613	0.3830	
B - D	-0.1194	0.2615	0.6425	
C - A	-0.6470	-0.2592	0.1287	
C - B	-0.3830	-0.0613	0.2605	
C - D	-0.1895	0.2003	0.5900	
D - A	-0.8976	-0.4594	-0.0213	***
D - B	-0.6425	-0.2615	0.1194	
D - C	-0.5900	-0.2003	0.1895	

GLM for f16 experience and satisfaction
General Linear Models Procedure

Class Level Information

Class Levels Values F16EXP 3 2
years, 2 years < 7 years, 7 years or more

Number of observations in data set = 375

GLM for f16 experience and satisfaction
General Linear Models Procedure

Dependent Variable: Satisfaction

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	3181.7282476	1060.5760825	1336.17	0.0001
Error	372	295.2717524	0.7937413		
Uncorrected Total	375	3477.0000000			

R-Square	C.V.	Root MSE	Satisfaction Mean
0.025240	30.62288	0.8909216	2.9093333

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	3174.0826667	3174.0826667	3998.89	0.0001
F16EXP	2	7.6455809	3.8227905	4.82	0.0086

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	2665.2842686	2665.2842686	3357.88	0.0001
F16EXP	2	7.6455809	3.8227905	4.82	0.0086

GLM for f16 experience and satisfaction
General Linear Models Procedure

Scheffe's test for variable: Satisfaction

NOTE: This test controls the type I experimentwise error rate
but generally has a higher type II error rate
than Tukey's for all pairwise comparisons.

Alpha= 0.05 Confidence= 0.95 df= 372 MSE= 0.793741
Critical Value of F= 3.01999
Comparisons significant at the 0.05 level are indicated
by '***'.

NOTE: < 2 years: A
2 years < 7 years: B
7 years or more: C

F16EXP Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
A - B	0.00106	0.26115	0.52124	***
A - C	0.05389	0.38750	0.72111	***
B - A	-0.52124	-0.26115	-0.00106	***
B - C	-0.17915	0.12635	0.43185	
C - A	-0.72111	-0.38750	-0.05389	***
C - B	-0.43185	-0.12635	0.17915	

GLM for fim experience and satisfaction
General Linear Models Procedure

Class Level Information

Class	Levels	Values
FIMEXP	3	< 2 years, 2 years < 7 years, 7 years or more

Number of observations in data set = 375
GLM for fim experience and satisfaction

General Linear Models Procedure

Dependent Variable: Satisfaction

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	3183.9703005	1061.3234335	1347.35	0.0001
Error	372	293.0296995	0.7877142		
Uncorrected Total	375	3477.0000000			

R-Square	C.V.	Root MSE	Satisfaction Mean
0.032641	30.50639	0.8875327	2.9093333

Source	DF	Type I SS	Mean Square	F Value	Pr > F
INTERCEPT	1	3174.0826667	3174.0826667	4029.48	0.0001
FIMEXP	2	9.8876338	4.9438169	6.28	0.0021

Source	DF	Type III SS	Mean Square	F Value	Pr > F
INTERCEPT	1	2356.7055414	2356.7055414	2991.83	0.0001
FIMEXP	2	9.8876338	4.9438169	6.28	0.0021

GLM for fim experience and satisfaction
General Linear Models Procedure

Scheffe's test for variable: Satisfaction

NOTE: This test controls the type I experimentwise error rate but generally has a higher type II error rate than Tukey's for all pairwise comparisons.

Alpha= 0.05 Confidence= 0.95 df= 372 MSE= 0.787714
Critical Value of F= 3.01999

Comparisons significant at the 0.05 level are indicated by '***'.

NOTE: < 2 years: A
2 years < 7 years: B
7 years or more: C

FIMEXP Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
A - B	0.00493	0.24843	0.49193	***
A - C	0.10858	0.45213	0.79569	***
B - A	-0.49193	-0.24843	-0.00493	***
B - C	-0.13904	0.20370	0.54645	
C - A	-0.79569	-0.45213	-0.10858	***
C - B	-0.54645	-0.20370	0.13904	

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AN EVALUATION OF FAULT ISOLATION MANUALS FROM THE MAINTENANCE TECHNICIAN'S PERSPECTIVE

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13. ABSTRACT *(Maximum 200 words)*

Studies to improve the way technicians isolate malfunctions have been on-going since at least 1954. Some significant improvements have resulted in the paper based fault isolation manuals used by maintenance technicians. However, problems with the manuals persist. To evaluate how maintenance technicians perceive the F-16 Fault Isolation Manual, technicians from six CONUS F-16 wings were surveyed. The data were statistically analyzed by the demographic factors of skill level, AFSC, grade, education level, base of assignment, maintenance experience, F-16 experience, and FIM experience, to determine if differences existed as to the maintenance technicians' perceptions of FIM usefulness, FIM accuracy, and satisfaction with the FIM. The results indicate that 1) differences exist for all demographic factors except grade and base of assignment, 2) technicians who use the FIM more perceive it to be more useful and accurate, and 3) technicians with more experience and education perceive the FIM to be less useful and accurate and are less satisfied with the FIM. The recommendations are that actions need to be taken to ensure technicians use the FIM as directed and to improve the accuracy of the FIM.

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